B. STEELHEAD

B.1. BACKGROUND AND HISTORY OF LISTINGS

Primary contributors: Thomas P. Good and Robin S. Waples
(Northwest Fisheries Science Center)

Background

Steelhead is the name commonly applied to the anadromous form of the biological species *Oncorhynchus mykiss*. The present distribution of steelhead extends from Kamchatka in Asia, east to Alaska, and down to southern California (NMFS 1999), although the historical range of *O. mykiss* extended at least to the Mexico border (Busby et al. 1996). *O. mykiss* exhibit perhaps the most complex suite of life-history traits of any species of Pacific salmonid. They can be anadromous or freshwater resident (and under some circumstances, apparently yield offspring of the opposite form). Those that are anadromous can spend up to 7 years in fresh water prior to smoltification, and then spend up to 3 years in salt water prior to first spawning. The half-pounder life-history type in Southern Oregon and Northern California spends only 2 to 4 months in salt water after smoltification, then returns to fresh water and outmigrates to sea again the following spring without spawning. This species can also spawn more than once (iteroparous), whereas all other species of *Oncorhynchus* except *O. clarki* spawn once and then die (semelparous). The anadromous form is under the jurisdiction of the National Marine Fisheries Service (NMFS), while the resident freshwater forms, usually called "rainbow" or "redband" trout, are under the jurisdiction of U. S. Fish and Wildlife Service (FWS).

Although no subspecies are currently recognized within any of the species of Pacific salmon, Behnke (1992) has proposed that two subspecies of *O. mykiss* with anadromous life history occur in North America: *O. mykiss irideus* (the "coastal" subspecies), which includes coastal populations from Alaska to California (including the Sacramento River), and *O. mykiss gairdneri* (the "inland" subspecies), which includes populations from the interior Columbia, Snake and Fraser Rivers. In the Columbia River, the boundary between the two subspecies occurs at approximately the Cascade Crest. A third subspecies of anadromous *O. mykiss* (*O. mykiss mykiss*) occurs in Kamchatka, and several other subspecies of *O. mykiss* are also recognized which only have resident forms (Behnke 1992).

Within the range of West Coast steelhead, spawning migrations occur throughout the year, with seasonal peaks of activity. In a given river basin there may be one or more peaks in migration activity; since these *runs* are usually named for the season in which the peak occurs, some rivers may have runs known as winter, spring, summer, or fall steelhead. For example, large rivers, such as the Columbia, Rogue, and Klamath rivers, have migrating adult steelhead at all times of the year. There are local variations in the names used to identify the seasonal runs of steelhead; in Northern California, some biologists have retained the use of the terms spring and fall steelhead to describe what others would call summer steelhead.

Steelhead can be divided into two basic reproductive ecotypes, based on the state of sexual maturity at the time of river entry, and duration of spawning migration (Burgner et al.

1992). The *stream-maturing* type (summer steelhead in the Pacific Northwest and Northern California) enters fresh water in a sexually immature condition between May and October and requires several months to mature and spawn. The *ocean-maturing* type (winter steelhead in the Pacific Northwest and Northern California) enters fresh water between November and April with well-developed gonads and spawns shortly thereafter. In basins with both summer and winter steelhead runs, it appears that the summer run occurs where habitat is not fully utilized by the winter run or a seasonal hydrologic barrier, such as a waterfall, separates them. Summer steelhead usually spawn farther upstream than winter steelhead (Withler 1966, Roelofs 1983, Behnke 1992). Coastal streams are dominated by winter steelhead, whereas inland steelhead of the Columbia River Basin are almost exclusively summer steelhead. Winter steelhead may have been excluded from inland areas of the Columbia River Basin by Celilo Falls or by the considerable migration distance from the ocean. The Sacramento-San Joaquin River Basin may have historically had multiple runs of steelhead that probably included both ocean-maturing and stream-maturing stocks (CDFG 1995, McEwan and Jackson 1996). These steelhead are referred to as winter steelhead by the California Department of Fish and Game (CDFG); however, some biologists call them fall steelhead (Cramer et. al 1995). It is thought that hatchery practices and modifications in the hydrology of the basin caused by large-scale water diversions may have altered the migration timing of steelhead in this basin (D. McEwan, pers. comm.).

Inland steelhead of the Columbia River Basin, especially the Snake River Subbasin, are commonly referred to as either *A-run* or *B-run*. These designations are based on a bimodal migration of adult steelhead at Bonneville Dam (235 km from the mouth of the Columbia River) and differences in age (1- versus 2-ocean) and adult size observed among Snake River steelhead. It is unclear, however, if the life-history and body size differences observed upstream are correlated back to the groups forming the bimodal migration observed at Bonneville Dam. Furthermore, the relationship between patterns observed at the dams and the distribution of adults in spawning areas throughout the Snake River Basin is not well understood. A-run steelhead are believed to occur throughout the steelhead-bearing streams of the Snake River Basin and the inland Columbia River; B-run steelhead are thought to be produced only in the Clearwater, Middle Fork Salmon, and South Fork Salmon Rivers (IDFG 1994).

The *half-pounder* is an immature steelhead that returns to fresh water after only 2 to 4 months in the ocean, generally overwinters in fresh water, and then outmigrates again the following spring. Half-pounders are generally less than 400 mm and are reported only from the Rogue, Klamath, Mad, and Eel Rivers of Southern Oregon and Northern California (Snyder 1925, Kesner and Barnhart 1972, Everest 1973, Barnhart 1986); however, it has been suggested that as mature steelhead, these fish may only spawn in the Rogue and Klamath River Basins (Cramer et al. 1995). Various explanations for this unusual life history have been proposed, but there is still no consensus as to what, if any, advantage it affords to the steelhead of these rivers.

In May 1992, NMFS was petitioned by the Oregon Natural Resources Council (ONRC) and 10 co-petitioners to list Oregon's Illinois River winter steelhead (ONRC et al. 1992). NMFS concluded that Illinois River winter steelhead by themselves did not constitute an ESA "species" (Busby et al. 1993, NMFS 1993a). In February 1994, NMFS received a petition seeking protection under the Endangered Species Act (ESA) for 178 populations of steelhead (anadromous *O. mykiss*) in Washington, Idaho, Oregon, and California. At the time, NMFS was conducting a status review of coastal steelhead populations (*O. m. irideus*) in Washington, Oregon, and California. In response to the broader petition, NMFS expanded the ongoing status review to include inland steelhead (*O. m. gairdneri*) occurring east of the Cascade Mountains in Washington, Idaho, and Oregon.

In 1995, the steelhead Biological Review Team (BRT) met to review the biology and ecology of West Coast steelhead. After considering available information on steelhead genetics, phylogeny, and life history, freshwater ichthyogeography, and environmental features that may affect steelhead, the BRT identified 15 ESUs—12 coastal forms and three inland forms. After considering available information on population abundance and other risk factors, the BRT concluded that five steelhead ESUs (Central California Coast, South-Central California Coast, Southern California, Central Valley, and Upper Columbia River) were presently in danger of extinction, five steelhead ESUs (Lower Columbia River, Oregon Coast, Klamath Mountains Province, Northern California, and Snake River Basin) were likely to become endangered in the foreseeable future, four steelhead ESUs (Puget Sound, Olympic Peninsula, Southwest Washington, and Upper Willamette River) were not presently in significant danger of becoming extinct or endangered, although individual stocks within these ESUs may be at risk, and one steelhead ESU (Middle Columbia River) was not presently in danger of extinction but the BRT was unable to reach a conclusion as to its risk of becoming endangered in the foreseeable future.

Of the 15 steelhead ESUs identified by NMFS, five are not listed under the ESA: Southwest Washington, Olympic Peninsula, and Puget Sound (Federal Register, Vol. 61, No. 155, August 9, 1996, p. 41558), Oregon Coast (Federal Register, Vol. 63, No. 53, March 19, 1998, p. 13347), and Klamath Mountain Province (Federal Register, Vol. 66, No. 65, April 4, 2001, p. 17845); eight are listed as threatened: Snake River Basin, Central California Coast and South-Central California Coast (Federal Register, Vol. 62, No. 159, August 18, 1997, p. 43937), Lower Columbia River, California Central Valley (Federal Register, Vol. 63, No. 53, March 19, 1998, p. 13347), Upper Willamette River, Middle Columbia River (Federal Register, Vol. 64, No. 57, March 25, 1999, p. 14517), and Northern California (Federal Register, Vol. 65, No. 110, June 7, 2000, p.36074), and two are listed as endangered: Upper Columbia River and Southern California (Federal Register, Vol. 62, No. 159, August 18, 1997, p. 43937).

The West Coast steelhead BRT[1] met in January, March, and April 2003 to discuss new data received and to determine if the new information warranted any modification of the conclusions of the original BRTs. This report summarizes new information and the preliminary BRT conclusions on the following ESUs: Snake River Basin, Upper Columbia River, Middle Columbia River, Lower Columbia River, Upper Willamette River, Northern California, Central California Coast, South-Central California Coast, Southern California, and California Central Valley.

[1] The biological review team (BRT) for the updated status review for West Coast steelhead included, from the NMFS Northwest Fisheries Science Center: Thomas Cooney, Dr. Robert Iwamoto, Gene Matthews, Dr. Paul McElhany, Dr. James Myers, Dr. Mary Ruckelshaus, Dr. Thomas Wainwright, Dr. Robin Waples, and Dr. John Williams; from NMFS Southwest Fisheries Science Center: Dr. Peter Adams, Dr. Eric Bjorkstedt, Dr. David Boughton, Dr. John Carlos Garza, Dr. Steve Lindley, and Dr. Brian Spence; from the U.S. Fish and Wildlife Service, Abernathy, WA: Dr. Donald Campton; and from the USGS Biological Resources Division, Seattle: Dr. Reginald Reisenbichler.

Resident fish

As mentioned earlier, *O. mykiss* exhibits varying degrees of anadromy. Non-anadromous forms are usually called rainbow trout; however, nonanadromous inland *O. mykiss* are often called Columbia River redband trout. A form that occurs in the upper Sacramento River is called Sacramento redband trout. Although the anadromous and nonanadromous forms have long been taxonomically classified within the same species, the exact relationship between the forms in any given area is not well understood. In coastal populations, it is unusual for the two forms to co-occur; they are usually separated by a natural or man-made migration barrier. Co-occurrence of the two forms in inland populations appears to be more frequent. Where they co-occur, "it is possible that offspring of resident fish may migrate to the sea, and offspring of steelhead may remain in streams as resident fish" (Burgner et al. 1992, p. 6; Shapovalov and Taft 1954). Mullan et al. (1992) found evidence that in very cold streams, juvenile steelhead had difficulty attaining mean threshold size for smoltification and concluded that most fish in the Methow River in Washington that did not emigrate downstream early in life were thermally-fated to a resident life history regardless of whether they were the progeny of anadromous or resident parents. Additionally, Shapovalov and Taft (1954) reported evidence of *O. mykiss* maturing in fresh water and spawning prior to their first ocean migration; this life-history variation has also been found in cutthroat trout (*O. clarki*) and some male chinook salmon (*O. tshawytscha*).

As part of this status review update process, a concerted effort was made to collect biological information for resident populations of *O. mykiss*. Information from listed ESUs in Washington, Oregon, and Idaho is contained in a draft report by Kostow (2003) and summarized in Appendix B.5.1; relevant information for specific ESUs is presented in subsequent sections. Information about resident *O. mykiss* populations in California is summarized in Appendix B.5.2.

The BRT had to consider in more general terms how to conduct an overall risk assessment for an ESU that includes both resident and anadromous populations, particularly when the resident individuals may outnumber the anadromous ones but their biological relationship was unclear or unknown. Some guidance is found in Waples (1991), which outlines the scientific basis for the NMFS ESU policy. That paper suggested that an ESU that contains both forms could be listed based on a threat to only one of the life-history traits “if the trait were genetically based and loss of the trait would compromise the ‘distinctiveness’ of the population” (p. 16). That is, if anadromy were considered important in defining the distinctiveness of the ESU, loss of that trait would be a serious ESA concern. In discussing this issue, the NMFS ESU policy (Federal Register 56:58612; 20 November 1991) affirmed the importance of considering the genetic basis of life-history traits such as anadromy, and recognized the relevance of a question posed by one commenter: “What is the likelihood of the nonanadromous form giving rise to the anadromous form after the latter has gone locally extinct?”

The BRT also discussed another important consideration, which is the role anadromous populations play in providing connectivity and linkages among different spawning populations within an ESU. An ESU in which all anadromous populations had been lost and the remaining resident populations were fragmented and isolated would have a very different future evolutionary trajectory than one in which all populations remained linked genetically and ecologically by anadromous forms. Furthermore, in many (if not all) *O. mykiss* ESUs, the geographic area utilized by anadromous (but not resident) fish may represent a "significant portion of the range" of the ESA species, especially if the area encompassed by the marine migration is considered.

In spite of concerted efforts to collect and synthesize available information on resident forms of *O. mykiss*, existing data are very sparse, particularly regarding interactions between resident and anadromous forms (Kostow 2003). The BRT was frustrated by the difficulties of considering complex questions involving the relationship between resident and anadromous forms, given this paucity of key information. To help focus this issue, the BRT considered a hypothetical scenario that has varying degrees of relevance to individual steelhead ESUs. In this scenario, the once-abundant and widespread anadromous life history is extinct or nearly so, but relatively healthy native populations of resident fish remain in many geographic areas. The question considered by the BRT was the following: Under what circumstances would you conclude that such an ESU was not in danger of extinction or likely to become endangered? The BRT identified the required conditions as:

1) The resident forms are capable of maintaining connectivity among populations to the extent that historical evolutionary processes of the ESU are not seriously disrupted;
2) The anadromous life history is not permanently lost from the ESU but can be regenerated from the resident forms.

Regarding the first criterion, although some resident forms of salmonids are known to migrate considerable distances in freshwater, extensive river migrations have not been demonstrated to be an important behavior for resident *O. mykiss*, except in rather specialized circumstances (e.g., forms that migrate from a stream to a large lake or reservoir as a surrogate for the ocean). Therefore, the BRT felt that loss of the anadromous form would, in most cases, substantially change the character and future evolutionary potential of steelhead ESUs. Regarding the second criterion, it is well established that resident forms of *O. mykiss* can occasionally produce anadromous migrants, and vice versa (Mullan et al. 1992, Zimmerman and Reeves 2000, Kostow 2003), just as has been shown for other salmonid species (e. g., *O. nerka,* Foerster 1947, Fulton and Pearson 1981, Kaeriyama et al. 1992; coastal cutthroat trout *O. clarki clarki,* Griswold 1996, Johnson et al. 1999; brown trout *Salmo trutta,* Jonsson 1985; and Arctic char *Salvelinus alpinus*, Nordeng 1983). However, available information indicates that the incidence of these occurrences is relatively rare, and there is even less empirical evidence that, once lost, a self-sustaining anadromous run can be regenerated from a resident salmonid population. Although this must have occurred during the evolutionary history of *O. mykiss,* the BRT found no reason to believe that such an event would occur with any frequency or within a specified time period. This would be particularly true if the conditions that promote and support the anadromous life history continue to deteriorate. In this case, the expectation would be that natural selection would gradually eliminate the migratory or anadromous trait from the population, as individuals inheriting a tendency for anadromy migrate out of the population but do not survive to return as adults and pass on their genes to subsequent generations.

Given the above considerations, the BRT focused primarily on information for anadromous populations in the risk assessments for steelhead ESUs. This was particularly true with respect to Case 3 resident fish populations, the vast majority of which are of uncertain ESU status.   However, as discussed below in the “BRT Conclusions” section, the presence of relatively numerous, native resident fish was considered to be a mitigating risk factor for some ESUs**.**

B.2.1. SNAKE RIVER BASIN STEELHEAD ESU

Primary contributor: Thomas Cooney
(Northwest Fisheries Science Center)

The Snake River steelhead ESU is distributed throughout the Snake River drainage system, including tributaries in southwest Washington, eastern Oregon and north/central Idaho (NMFS, 1996). Snake River steelhead migrate a substantial distance from the ocean (up to 1,500 km) and use high elevation tributaries (typically 1,000-2,000 m above sea level) for spawning and juvenile rearing. Snake River steelhead occupy habitat that is considerably warmer and drier (on an annual basis) than other steelhead ESUs. Snake River basin steelhead are generally classified as summer run, based on their adult run timing patterns. Summer steelhead enter the Columbia River from late June to October. After holding over the winter, summer steelhead spawn during the following spring (March to May). Managers classify up-river summer steelhead runs into to groups based primarily on ocean age and adult size upon return to the Columbia River. A-run steelhead are predominately age-1 ocean fish while B-run steelhead are larger, predominated by age-2 ocean fish.

With the exception of the Tucannon River and some small tributaries to the mainstem Snake River, the tributary habitat used by Snake River steelhead ESU is above Lower Granite Dam. Major groupings of populations and/or subpopulations can be found in 1) the Grande Ronde River system; 2) the Imnaha River drainage; 3) the Clearwater River drainages; 4) the South Fork Salmon River; 5) the smaller mainstem tributaries before the confluence of the mainstem; 6) the Middle Fork salmon production areas, 7) the Lemhi and Pahsimeroi valley production areas and 8) upper Salmon River tributaries.

Resident *O. mykiss* are believed to be present in many of the drainages utilized by Snake River steelhead. Very little is known about interactions between co-occurring resident and anadromous forms within this ESU. The following review of abundance and trend information focuses on information directly related to the anadromous form.

Historical Returns

Although direct historical estimates of production from the Snake basin are not available, the basin is believed to have supported more than half of the total steelhead production from the Columbia basin (Mallet 1974). There are some historical estimates of returns to portions of the drainage. Lewiston Dam, constructed on the lower Clearwater, began operation in 1927. Counts of steelhead passing through the adult fish ladder at the dam reached 40-60,000 in the early 1960s (Cichosz et al. 2001). Based on relative drainage areas, the Salmon River basin likely supported substantial production as well. In the early 1960s, returns to the Grande Ronde River and the Imnaha River may have exceeded 15,000 and 4,000 steelhead per year, respectively (ODFW 1991). Extrapolations from tag/recapture data indicate that the natural steelhead return to the Tucannon River may have exceeded 3,000 adults in the mid-1950s (WDF 1991).

B.2.1.1. Summary of Previous BRT Conclusions

The primary concern regarding Snake River steelhead identified in the 1998 status review was a sharp decline in natural stock returns beginning in the mid-1980s. Of 13 trend indicators at that time, nine were in decline and four were increasing. In addition, Idaho Department of Fish and Game parr survey data indicated declines for both A and B run steelhead in wild and natural stock areas. The high proportion of hatchery fish in the run was also identified as a concern, particularly because of the lack of information on the actual contribution of hatchery fish to natural spawning. The review recognized that some wild spawning areas have relatively little hatchery spawning influence (Selway River, lower Clearwater River, the Middle and South forks of the Salmon River and the lower Salmon River). In other areas, such as the upper Salmon River, there is likely little or no natural production of locally native steelhead. The review identified threats to genetic integrity from past and present hatchery practices as a concern. Concern for the North Fork Clearwater stock was also identified. That stock is currently maintained through the Dworshak Hatchery program but cut off from access to its native tributary by Dworshak Dam. The 1998 review also highlighted concerns for widespread habitat degradation and flow impairment throughout the Snake basin as well as for the substantial modification of the seaward migration corridor by hydroelectric power development on the Snake and Columbia mainstem.

Previous Abundance

Although direct historical estimates of production from the Snake basin are not available, the basin is believed to have supported more than half of the total steelhead production from the Columbia basin (Mallet 1974). There are some historical estimates of returns to portions of the drainage. Lewiston Dam, constructed on the lower Clearwater, began operation in 1927. Counts of steelhead passing through the adult fish ladder at the dam reached 40-60,000 in the early 1960s (Cichosz et al. 2001). Based on relative drainage areas, the Salmon River basin likely supported substantial production as well. In the early 1960s, returns to the Grande Ronde River and the Imnaha River may have exceeded 15,000 and 4,000 steelhead per year, respectively (ODFW 1991). Extrapolations from tag/recapture data indicate that the natural steelhead return to the Tucannon River may have exceeded 3,000 adults in the mid-1950s (WDF 1991).

The previous status review noted that the aggregate trend in abundance as measured by ladder counts at the upper most Snake River dam (Lower Granite Dam since 1972) has been upward since the mid-1970s while the aggregate return of naturally produced steelhead was downward for the same period (Table B.2.1.1). The decline in natural production was especially pronounced in the later years in the series.

Table B.2.1.1. Summary of abundance and trend estimates for Snake River Steelhead ESU. Interim delisting target levels are explained in text. Estimates from previous status review in brackets.

Population(s)	5-year mean % natural origin	Recent Five-Year Geometric Mean			Short-term Trend (%/yr)		Interim Target	Current vs. Target
		Total	Natural					
		Mean (Range)	Current	Previous	Current	Previous		
Tucannon **	26 [44]	407 (257 – 628)	106	140	-3.7	-18.3	1,300	8%
Lower Granite Run*	14	106,175 (70,721- 259,145)	14,864	9,500	+6.1	+6.9	52,100	29%
Snake A run*	15	87,842 (50,974 – 25,950)	12,667		+8.5			
Snake B run*	11	17,305 (9,736– 33,195)	1,890		-0.6			
Asotin Cr++	?	87 Exp. Redds (0 – 543)		200	+4.0	-19.7	500	
Upper Grande Ronde+	77	1.54 RPM (0.3 – 4.7)			-2.9			
Joseph Cr	100^	1,542 (1,077 – 2,385)	1,542		+5.0		1,400	110%
Imnaha+	80	3.7 RPM (2.0 – 6.8)			-3.7			
Camp Creek	100^	155 (55 – 307)	155	80	+2.0	+1.7		

* 5-year geometric mean calculated using years 1997–2001
** 5-year geometric mean calculated using years 1999–2001
\+ 5-year geometric mean calculated using years 1996–2000
++ 5-year geometric mean calculated using years 1998–2001
^ Assumed, no hatchery releases into basin

B.2.1.2. New Data and Updated Analyses

Estimates of annual returns to specific production areas are not available for most of the Snake River ESU. Estimates are available for two tributaries below Lower Granite Dam (Tucannon and Asotin Creek). Annual ladder counts at Lower Granite Dam and associated sampling information allows for an estimate of the aggregate returns to the Snake River basin. In addition, area specific estimates are available for the Imnaha River and two major sections of the Grande Ronde River system. Updated estimates of return levels are summarized in Table B.2.1.1. Returns to Lower Granite Dam remained at relatively low levels through the 1990s; the 2001 run size at Lower Granite Dam was substantially higher relative to the 1990s. The recent geometric mean abundance was down for the Tucannon River relative to the last BRT status review. Returns to the Imnaha River and to the Grande Ronde River survey areas were generally higher relative to the early 1990s.

Overall, long-term trends remained negative for four of the nine available series (including aggregate measures and specific production area estimates; Figure B.2.1.7). Short-term trends improved relative to the period analyzed for the previous status review. The median short-term trend was +2.0% for the 1990-2001 period. Five out of the nine data sets showed a positive trend (Figure B.2.1.8).

IDFG has provided updated analyses of parr density survey results through 1999. IDFG concluded that "generational parr density trends, which are analogous to spawner to spawner survivorship, indicate that Idaho spring-summer chinook and steelhead with and without hatchery influence failed to meet replacement for most generations competed since 1985 (IDFG 2002). These data do not reflect the influence of increased returns in 2001 and 2002.

Population growth rate (λ) estimates for Snake River steelhead production areas (Table B.2.1.2, Figures B.2.1.6, B.2.1.7) demonstrate a similar pattern when compared to the simple trend analysis described above. The median long-term λ estimate across the nine series was 0.998 assuming that natural returns are produced only from natural-origin spawners and 0.733 if both hatchery and wild potential spawners are assumed to have contributed to production at the same rate-. Short-term λ estimates are higher, 1.013, assuming a hatchery effectiveness of 0, and .753, assuming hatchery and wild fish contribute to natural production in proportion to their numbers. These values are consistent with another recent analysis of population growth rates (McClure et al. 2003), which estimated λ at the ESU-level as 0.96 if hatchery fish do not reproduce, and 0.73 if they reproduce at a rate equal to that of wild fish. This analysis spanned the time period from 1980-2000, making it clear that the most recent returns have had an influence on lambda estimates, particularly in the short-term. [Note that population growth rate calculations in the Biological Opinion on the Federal Columbia River Power System (NMFS 2000) used assumptions of hatchery fish effectiveness bracketed by those in McClure et al. 2003.]

The standarized abundance trend and population growth rate estimates provided in this report do not explicitly differentiate potential density dependent effects from density independent survival effects. Abundance levels for many of the production areas considered in the analyses varied over a wide range. In several cases, it is likely that abundance, at least in some years, could be high enough to affect survival through density dependent mechanisms. To provide perspective on the potential for density dependent influences, recent geometric mean spawner abundance estimates are contrasted with interim delisting levels provided by NOAA fisheries regional office (http://www.nwr.noaa.gov/occd/InterimTargets.html). Interim delisting levels for Snake River spring/summer chinook production units were derived from recommendations of the Bevan Recovery Team. Interim delisting levels for upper Columbia spring chinook and steelhead were from Ford et al. (2001). The method described in Ford et al. (2001) was used to develop interim delisting levels for Mid-Columbia and Snake River steelhead production areas. The approach uses estimates of habitat area and, where available, estimates of spawning escapements during historical periods of high, sustained returns.

Table B.2.1.2 Snake River Steelhead. Population growth rate analysis. Summary of available trend data sets, results of calculating annual population growth rates (λ: geomean, probability geomean less than 1.0) Long-term = the length of the available data series, Short term = 1990 -2001 or most recent year. Population growth rates calculated for two hatchery effectiveness (HF) assumptions; HF = 0.0 hatchery fish available to spawn do not contribute to natural production, HF = 1.0 hatchery returns available to spawn contribute to broodyear natural production at the same rate as natural-origin spawners. Methods: DC – Dam counts; RC – redd counts; RPM – redds per mile index; TLC – estimated total live fish on spawning grounds, N/A – not available.

Snake River Steelhead	Series Length	Method	% wild 1987-1996	% wild 1997-2001	1997-2001 geomean	HF	Long-term λ	Prob. λ<1	Short-term λ	Prob. λ<1
Lower Granite Dam - Aggregate	1990-2001	DC	0.18	0.14	14,768	0 1	0.994 0.703	0.551 1.000	1.051 0.687	0.297 0.999
Lower Granite Dam – A run	1985-2001	DC	0.18	0.15	12,666	0 1	0.998 0.674	0.512 1.000	1.078 0.692	0.215 0.999
Lower Granite Dam - B run	1985-2001	DC	0.18	0.11	1,890	0 1	0.927 0.655	0.915 1.000	0.941 0.646	0.782 1.000
Tucannon River	1987-2001	DC	0.39	0.26	95	0 1	0.886 0.733	0.998 0.998	0.924 0.712	0.895 0.988
Grand Ronde River - Upper	1967-2000	RPM	0.83	0.77	N/A	0 1	0.967 0.951	0.668 0.736	1.013 0.958	0.436 0.705
Grand Ronde River - Joseph Creek	1974-2002	TLC	1.00	1.00	1,542	N/A	1.069	0.130	1.018	0.418
Imnaha River	1974-2000	RPM	0.80	0.80	N/A	0 1	1.042 1.026	0.242 0.534	0.929 0.899	0.873 0.927
Imnaha River - Camp Creek	1974-2002	TLC	1.00	1.00	154	N/A	1.077	0.099	1.007	0.460
Imnaha River - Little Sheep Creek	1985-2002	TLC	0.30	0.14	42	0 1	1.045 0.718	0.323 0.998	1.082 0.794	0.267 0.984

Resident *O. mykiss* considerations

The available information on resident *O. mykiss* populations within the ESU is summarized in Table B.2.1.3 and Appendix B.5.1 and provides a broad overview of the distribution of Case 1, 2, and 3 resident populations within the ESU. See the section on Resident Fish in the Introduction section to the main body of this report for an explanation of the three cases and their relevance to ESU determinations. The section on Resident Fish in section B.1 of this steelhead report discusses how resident fish are considered in risk analyses.

Kostow (2003) has reviewed information on the abundance and distribution of resident trout for this ESU. IDFG presence/absence survey results indicate that *O. mykiss* were found in 48% of the 84 streams sampled throughout the Salmon River Basin. Westslope Cutthroat Trout were found in 43% of the locations sampled. When the species co-occurred in a tributary system, the cutthroat trout tended to be found in smaller headwater tributaries, while *O. mykiss* were in larger tributaries lower in the system. Steelhead occupied lower mainstem and associated tributaries. IDFG has suggested that some of the resident rainbow in the Salmon and Clearwater drainages may be the result of hatchery rainbow introductions.

The relative abundance of resident *O. mykiss* in the Imnaha and Grande Ronde River basins has not been clearly defined. *O. mykiss* production has been documented in both basins. Kostow (2003) reports that while no formal surveys of resident trout abundance have been conducted in the Imnaha River basin, the results of genetics sampling in the basin support the presence of a resident form. Resident O. mykiss abundance in the Tucannon River is believed to be relatively low based on observations during steelhead redd count surveys (Kostow 2003).

Resident *O. mykiss* populations are present above the Hells Canyon Dam complex, but their relationship to existing steelhead populations below the dams has not been determined (Kostow 2003). There have been relatively few specific studies of potential relationships between sympatric resident and anadromous *O. mykiss* in the Snake River basin.

Table B.2.1.3. Distribution of *O. mykiss* trout by category relative to the Snake Basin steelhead ESU. Only major barriers are noted; numerous small barriers, both natural and artificial, also exist. Many other natural barriers are present but have *O. clarki* trout, rather than *O. mykiss* trout, above them. *O. mykiss* trout distribution in areas of sympatry with steelhead may be restricted in some areas if native *O. clarki* trout are also in the basin. The generalized listing of basins and subbasins does not imply that these constitute single trout populations or that trout distribution is continuous throughout the areas listed. Detailed trout distribution is usually unknown and actual demographically independent trout populations have not been described. All current trout distributions are decreased from historical distributions. In particular many mainstem and lower basin tributary are no longer used but probably were historically. Many current trout populations are only in upper basins and are highly fragmented.

ESU	**Category 1 Trout Populations (Sympatric)**	**Category 2 Trout Populations (Major Natural Barriers)**	**Category 3 Trout Populations (Major Artificial Barriers)**
Snake River Basin steelhead	Potentially all areas that are/were used by steelhead. Tucannon Asotin Grande Ronde Imnaha Salmon found in about 43% of streams Clearwater Selway Other areas?	Palouse River Malad River Several Hells Canyon tributaries Upper Malheur Basin "recent" disconnect from lower Malheur Lakes Basin	Trout distributions currently more restricted than historically North Fork Clearwater (Dworshak Dam) Mainstem Snake (Hells Canyon Dam) Powder Burnt Malheur Owyhee Weiser Payette Boise Burneau Salmon Falls Cr. Several small tributaries

Genetic analysis of Case 3 resident *O. mykiss* above Dworshak Dam shows that the sampled population is genetically more similar to Dworshak steelhead than are other Snake River *O. mykiss* populations (Waples 1998; Waples et al. 1993). This suggests that the sampled population may be derived primarily from residualized steelhead or native resident fish from the North Fork Clearwater River. However, the genetic data cannot rule out some introgression from non-native rainbow trout.

Kostow (2003) reported that field biologists noted spatial and temporal overlaps in spawning between resident and anadromous *O. mykiss* in the Grande Ronde, Imnaha, Tucannon and Upper Snake River basins. ODFW is conducting experimental cross breeding studies using resident and anadromous *O. mykiss* from the Grande Ronde Basin. Preliminary results indicate that all potential crosses produce outmigrating smolts. Steelhead x steelhead crosses had the highest smolt production rate and resident trout x resident trout crosses had the lowest. Adult female steelhead x resident male trout crosses, the combination most likely to occur in nature, had the second highest smolt production rate. Adult returns from the study are forthcoming.

Wishard et al. (1984), Williams et al. (1996), and Leary (2001) have genetically examined Case 3 resident populations in tributaries above the Hells Canyon Dam complex and have concluded that some populations are native redband trout but others are hybridized with hatchery rainbow trout. A number of genetic studies of Snake River *O. mykiss* that are currently underway should provide more specific information about resident populations in the future.

B.2.1.3. New Hatchery Information

Artificial production history

Almost all artificial production of steelhead within the Snake River ESU has been associated with two major mitigation initiatives—the Lower Snake River Compensation Program (LSRCP) and the mitigation program for Dworshak Dam on the North Fork of the Clearwater River. The LSRCP is administered by the USFWS and was established as compensation for losses incurred as a result of the construction and operation of the four lower Snake River hydroelectric dams. Production under this initiative generally began in the mid 1980s. The Dworshak mitigation program provides for artificial production as compensation for the loss of access to the North Fork Clearwater, a major historical production area. Dworshak Hatchery, completed in 1969, is the focus for that production.

Hatchery releases of steelhead within the Snake River ESU are summarized by time period and production area in Table B.2.1.4. The following sections summarize historical and current artificial production programs for steelhead by major geographic area within the ESU.

Table B.2.1.4. Hatchery releases of steelhead in the Snake River basin, organized by major steelhead production areas and broodstock of the release. Averages calculated by time period to facilitate comparison of release levels since the last BRT review with previous levels.

Basin	**Stock**	**Average releases per year**		
		1985 - 1989	**1990 - 1994**	**1995 - 2001**
Mainstem Snake	Dworshak B	2,400	1,760	-
	Lyons Ferry	141,383	72,306	73,616
	Oxbow A	912,769	651,723	440,999
	Salmon River A	68,800	-	93,325
	Wallowa	205,133	138,915	-
	Wells	112,559	-	-
	Mixed	20,352	-	-
	Imnaha River	-	6,722	-

	Snake River A			95,018
	Pahsimeroi A	-	8,695	-
	Mainstem Total	1,463,397	880,123	702,958
Tucannon	Lyons Ferry	32,300	14,116	151,723
	Tucannon River	157,469	62,860	8,574
	Wallowa	16,197	-	-
	Wells	40,229	-	-
	Pahsimeroi A	-	23,852	-
	Mixed	-	26,008	-
	Tucannon Total	246,197	126,838	160,297
Asotin	Lyons Ferry	16,895	6,092	16,328
	Oxbow A	-	27,200	-
	Pahsimeroi A	-	27,569	-
	Wallowa	5,800	-	-
	Wells	8,930	-	-
	Asotin Total	31,625	60,861	16,328
Mainstem Clearwater	Dworshak B	1,618,440	1,893,944	1,755,111
	Clearwater B	-	-	113,581
North Fork Clearwater	Dworshak B	-	-	391,210
South Fork Clearwater	Clearwater B	-	-	85,398
	Dworshak B	612,152	869,839	739,543
	Selway River	-	14,313	19,483
	Clearwater Total	2,230,593	2,778,097	3,104,325
Mainstem Grande Ronde	Wallowa	782,060	616,379	975,089
Wallowa	Wallowa	529,852	985,339	524,416
	Grande Ronde Total	1,311,912	1,601,718	1,499,505
Lower & Mainstem Salmon	Salmon River A	325,000	432,867	161,537
	Salmon River B	9,900	-	24,940
	Dworshak B	-	112,291	109,015
Basin	**Stock**	**Average releases per year**		
		1985 - 1989	**1990 - 1994**	**1995 - 2001**
	Oxbow A	-	100,972	63,879
	Pahsimeroi A	-	235,306	68,695
Little Salmon	Hagerman A	61,621	-	-
	Oxbow A	120,261	200,380	341,639
	Salmon River A	399,135	232,716	271,400
	Dworshak B	-	367,068	222,438
	Pahsimeroi A	-	65,632	39,933
	Salmon River B	-	-	48,471
Panther	Pahsimeroi A	49,264	-	-
	Salmon River A	141,100	-	-

North Fork Salmon	Salmon River A	92,300	71,600	30,070
	Oxbow A	-	26,995	-
	Pahsimeroi A	-	38,100	43,500
Lemhi	Dworshak B	125,000	86,857	-
	Pahsimeroi A	-	-	132,741
	Salmon River A	-	-	129,287
Pahsimeroi	Pahsimeroi A	845,968	693,118	718,435
	Salmon River A	-	-	114,506
East Fork Salmon	E Fk Salmon B	475,023	197,670	34,283
	Dworshak B	87,315	773,329	240,523
	Hagerman B	54,042	-	-
	Salmon River B	-	-	71,494
Upper Salmon	Hagerman A	157,237	-	-
	Pahsimeroi A	-	447,944	368,748
	Salmon River A	889,353	669,844	590,289
	Dworshak B	-	-	130,186
	Salmon River B	-	-	18,387
	Sawtooth A	-	-	32,348
	Salmon Total	3,832,518	4,752,697	4,006,745
Imnaha	Imnaha River	188,275	325,833	169,758
	Little Sheep Creek	-	-	131,776
	Imnaha Total	188,275	325,833	301,534
ESU Total	All Stocks	10,097,233	10,526,167	10,033,360

Tucannon River—Artificial production of steelhead in the Tucannon River has been carried out since the early 1980s in response to the LSRCP objective of 878 steelhead to the project area. Until 1998, releases of hatchery steelhead into the Tucannon River occurred via the upriver Curl Lake acclimation site. Release numbers ranged from 120,000 to 160,000 between 1985 and 1997. The broodstock for Tucannon releases was primarily the Lyons Ferry stock, which was originally derived from Wells Hatchery and Wallowa Hatchery stocks. The Wallowa Hatchery stock was originally derived by ODFW through trapping returning adults in the lower Snake River. Pahsimeroi Hatchery stock was used in the program in one year when full production was lost at Lyons Ferry due to disease outbreaks, primarily IHNV (Gephart and Nordheim 2001).

Return rates to the Tucannon River from the hatchery program have been relatively low. Beginning in 1998, the release location for hatchery steelhead was moved down river in response to studies indicating improved survivals from lower river releases and to minimize the opportunity for interbreeding between hatchery and natural returns (included listed spring chinook) to the basin. Beginning with the 1999/2000-cycle year, the Tucannon River hatchery steelhead program began an evaluation of the feasibility of using local broodstock for the program. A full switch over to an endemic broodstock may occur in the future, depending upon the success of the pilot program. Problems associated with trapping and rearing of the new broodstock, as well as genetic questions still need to be addressed (B. Leland WDFW, pers. comm.).

Grande Ronde/Imnaha Rivers—There are LSRCP steelhead hatchery mitigation releases in the Grande Ronde and Imnaha River systems. The LSRCP compensation objective for Grande Ronde steelhead returns is 9,200. Trapping facilities for adult broodstock are located at Big Canyon Creek acclimation site. The original program used outside broodstock (including Skamania Hatchery stock) from 1979-1982 before switching to the Wallowa broodstock. Smolts are acclimated and released at two sites—one within the Wallowa drainage, the other at Big Canyon Creek. Oregon manages the Minam River, Joseph Creek and the Wenaha River drainages for natural production. Other sections of the Grande Ronde have been outplanted to supplement natural production (Nowak 2001).

LSCRP program releases into the Imnaha River are released from a satellite facility on Little Sheep Creek after primary rearing at Wallowa Hatchery. Additional releases are targeted in Horse Creek and the Upper Imnaha basin (Bryson 2001).

Clearwater Basin—Steelhead hatchery releases into the Clearwater basin are managed under two programs—LRSCMP and Dworshak Dam mitigation. The Lower Snake Compensation Plan program in the Clearwater River drainage utilizes the Clearwater hatchery as a central rearing facility and has an overall production objective of 14,000 adult steelhead returns to the Snake River. Program release sites include acclimation ponds on the Powell River (Lochsa River drainage), the Red River, and Crooked River sites in the South Fork of the Clearwater River. The Dworshak mitigation program has an adult return objective of 20,000 adult steelhead as compensation for losses due to Dworshak Dam, an anadromous block that cuts off the North Fork of the Clearwater River. Genetics studies have indicated that the hatchery stock used in the Dworshak program may be representative of the original North Fork run (Cichosz et al. 2001).

Salmon River Basin—Steelhead hatchery releases into the Salmon River drainage are under the auspices of two major steelhead hatchery programs—LSRCP and Idaho Fish and Game Department programs funded by Idaho Power Company. In addition, there are state and tribal experimental supplementation programs in the drainage. The LSRCP program goal for the Salmon basin is to produce an annual return of 25,000 adult steelhead above Lower Granite Dam. Juvenile steelhead produced at Magic Valley Hatchery and Hagerman National Fish Hatchery are released into the Salmon drainage. The Idaho Power Company-funded program for steelhead has an objective of releasing 400,000 pounds of steelhead smolts (Servheen 2001).

The Middle Fork Salmon drainages have had minimal or no hatchery releases. The Upper Salmon drainages, the Pahsimeroi, Lemhi, Little Salmon River and Lower Salmon River areas have received releases in recent years.

Categorizations of hatchery Snake River Basin hatchery stocks (SSHAG 2003) are summarized in Appendix B.5.3.

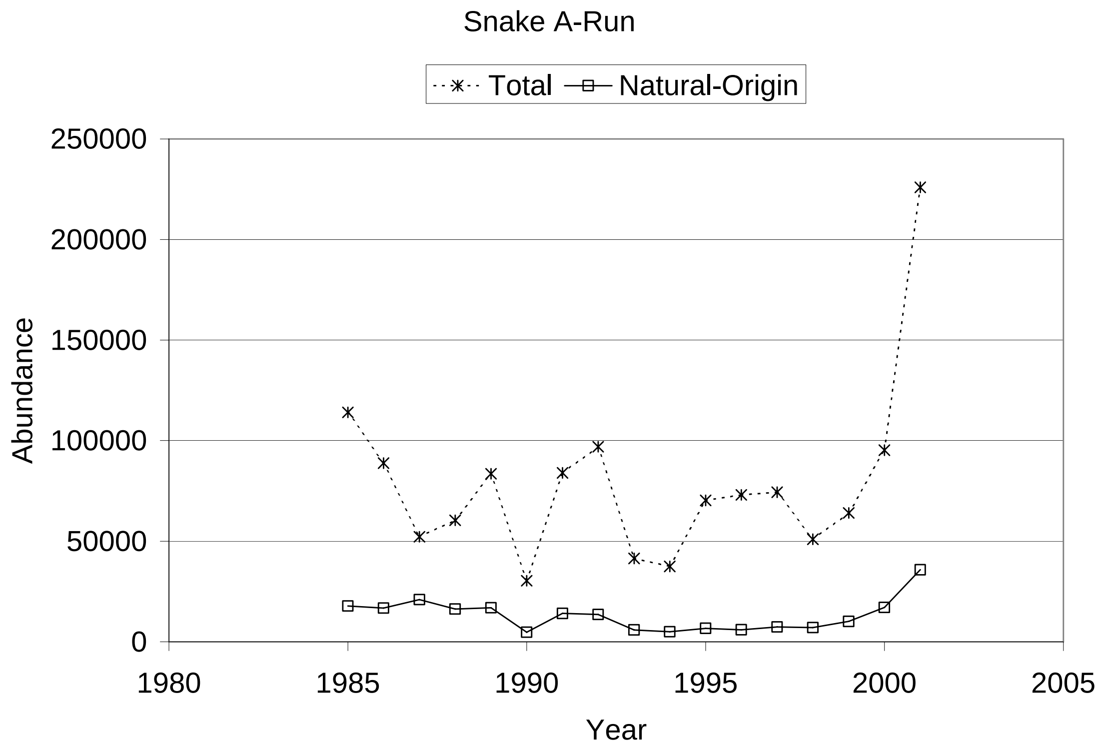


Figure B.2.1.1. Lower Granite Dam counts of Snake River A-run steelhead: US v Oregon Technical Advisory Committee estimates (source: H. Yuen, USFWS, Vancouver, WA).

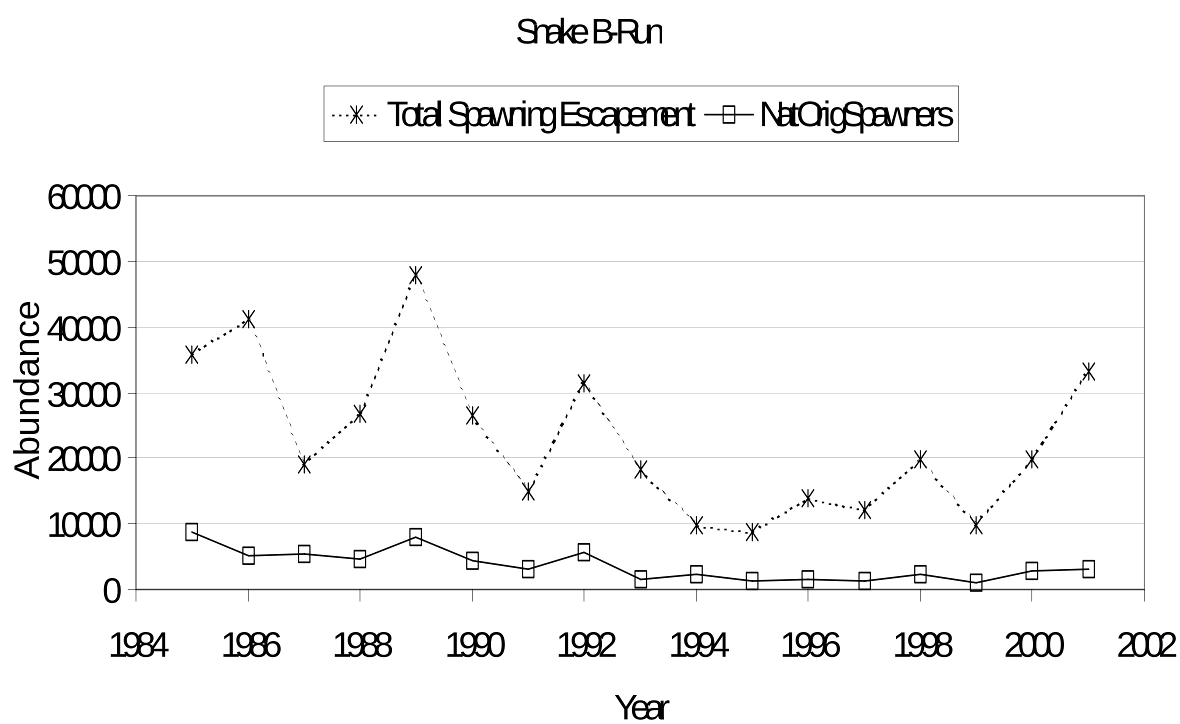


Figure B.2.1.2. Lower Granite Dam counts of Snake River B-run steelhead: US v Oregon Technical Advisory Committee estimates (source: H. Yuen, USFWS, Vancouver, WA).

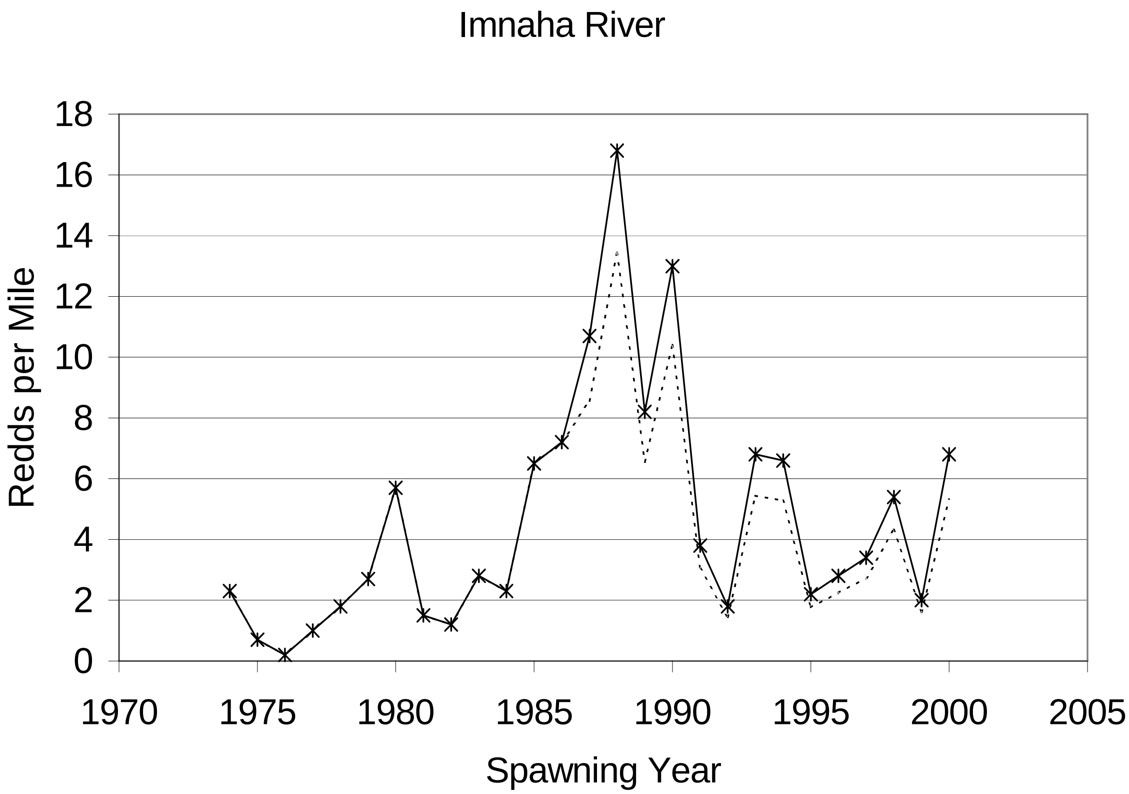


Figure B.2.1.3. Spawner abundance counts (redds/mile) for Imnaha River steelhead.

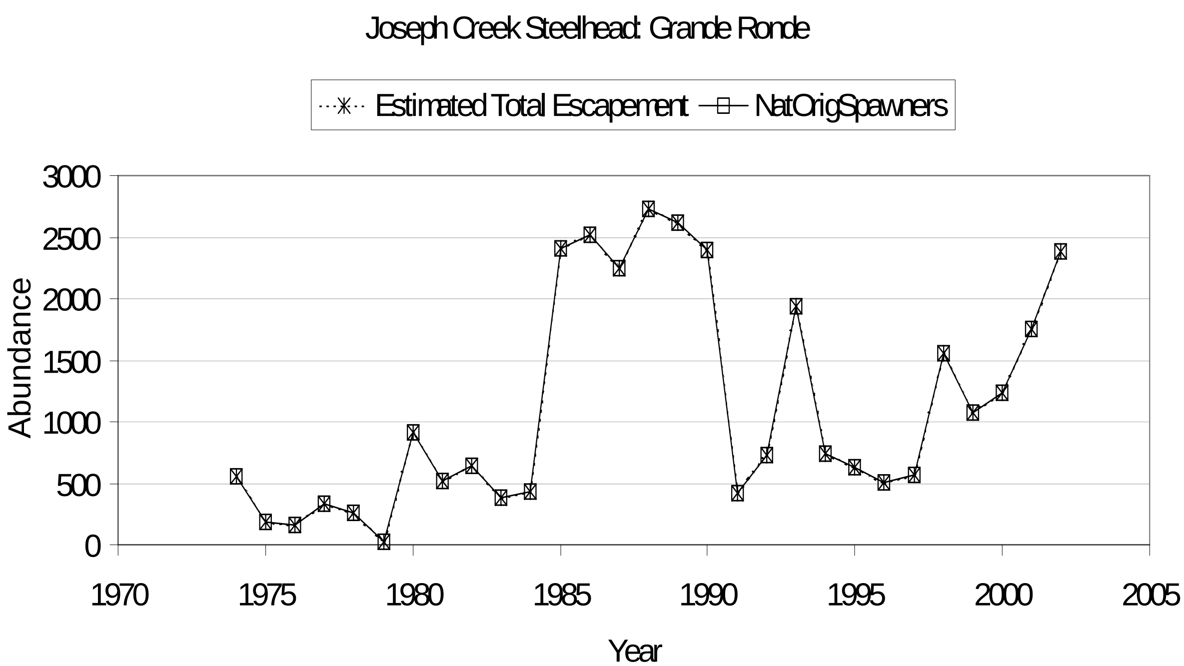


Figure B.2.1.4. Spawner escapement for Joseph Creek steelhead: Grande Ronde. Expanded from redd counts (ODFW).

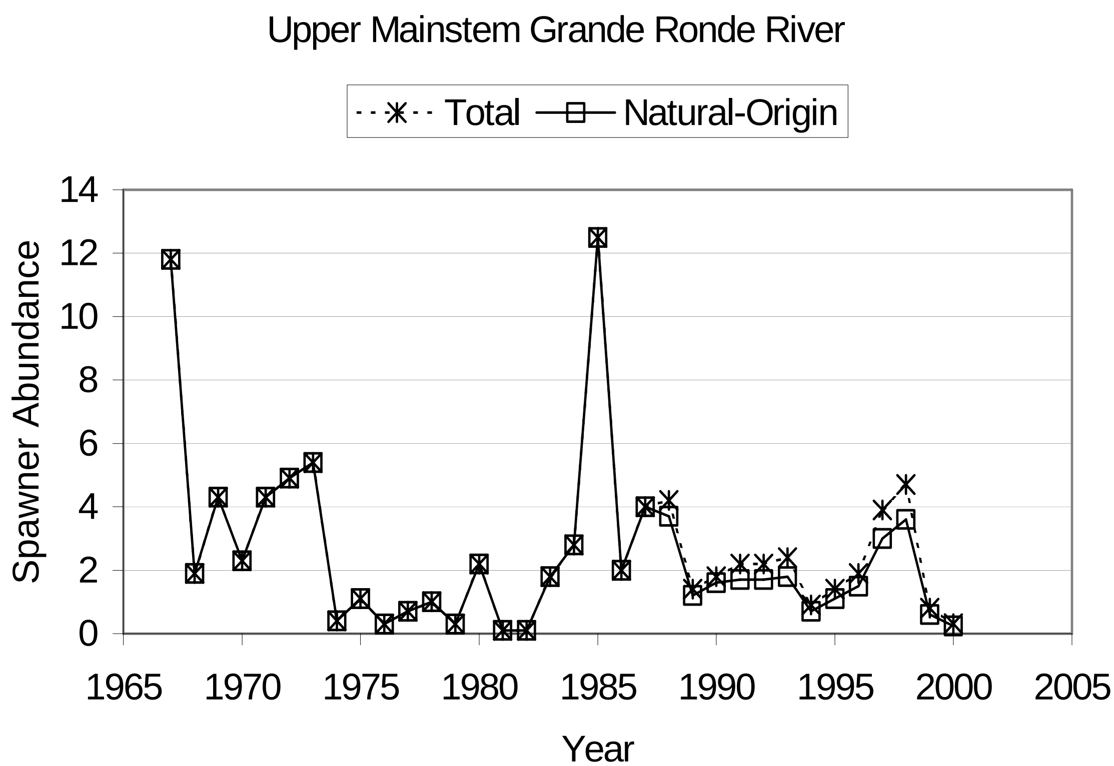


Figure B.2.1.5. Spawner escapement for the Upper Mainstem Grande Ronde River (ODFW spawning ground survey data).

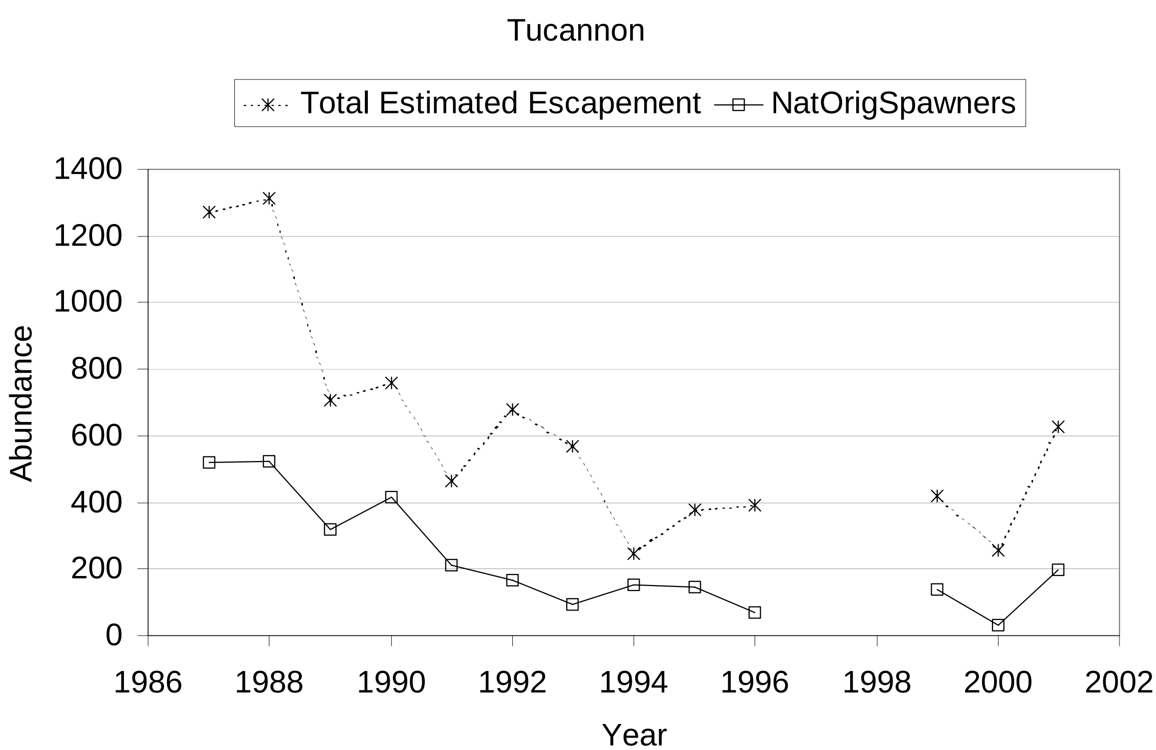


Figure B.2.1.6. Estimated spawner escapement for Tucannon River steelhead (WDFW).

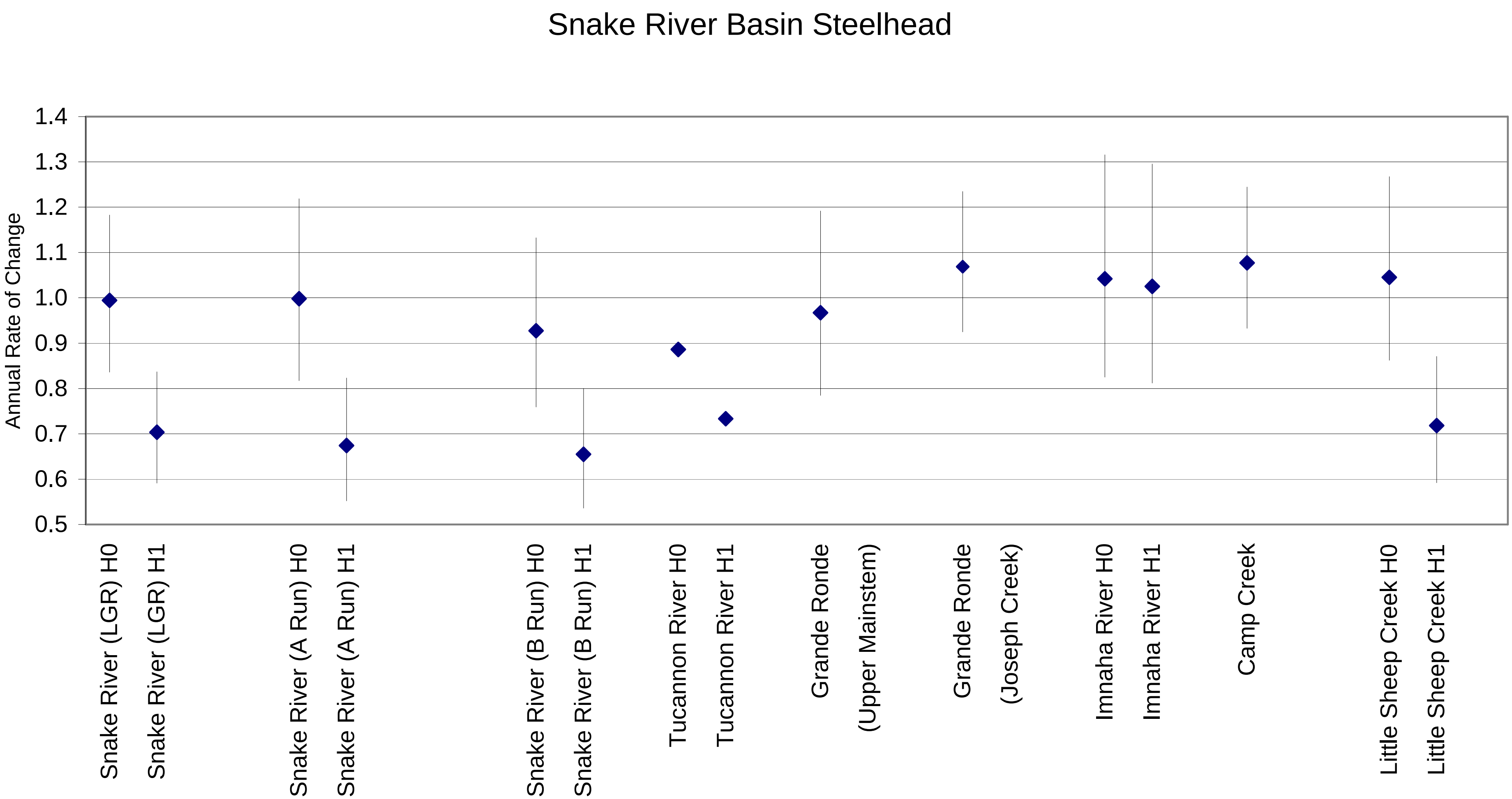


Figure B.2.1.7. Long term median population growth rate estimates and 95% confidence limits for the Snake River Basin steelhead ESU. Paired estimates are based on calculations where hatchery-origin spawners have reproductive success equal to zero (H0) or equivalent to natural-origin spawners (H1) (some hatchery confidence limits estimated by extrapolation).

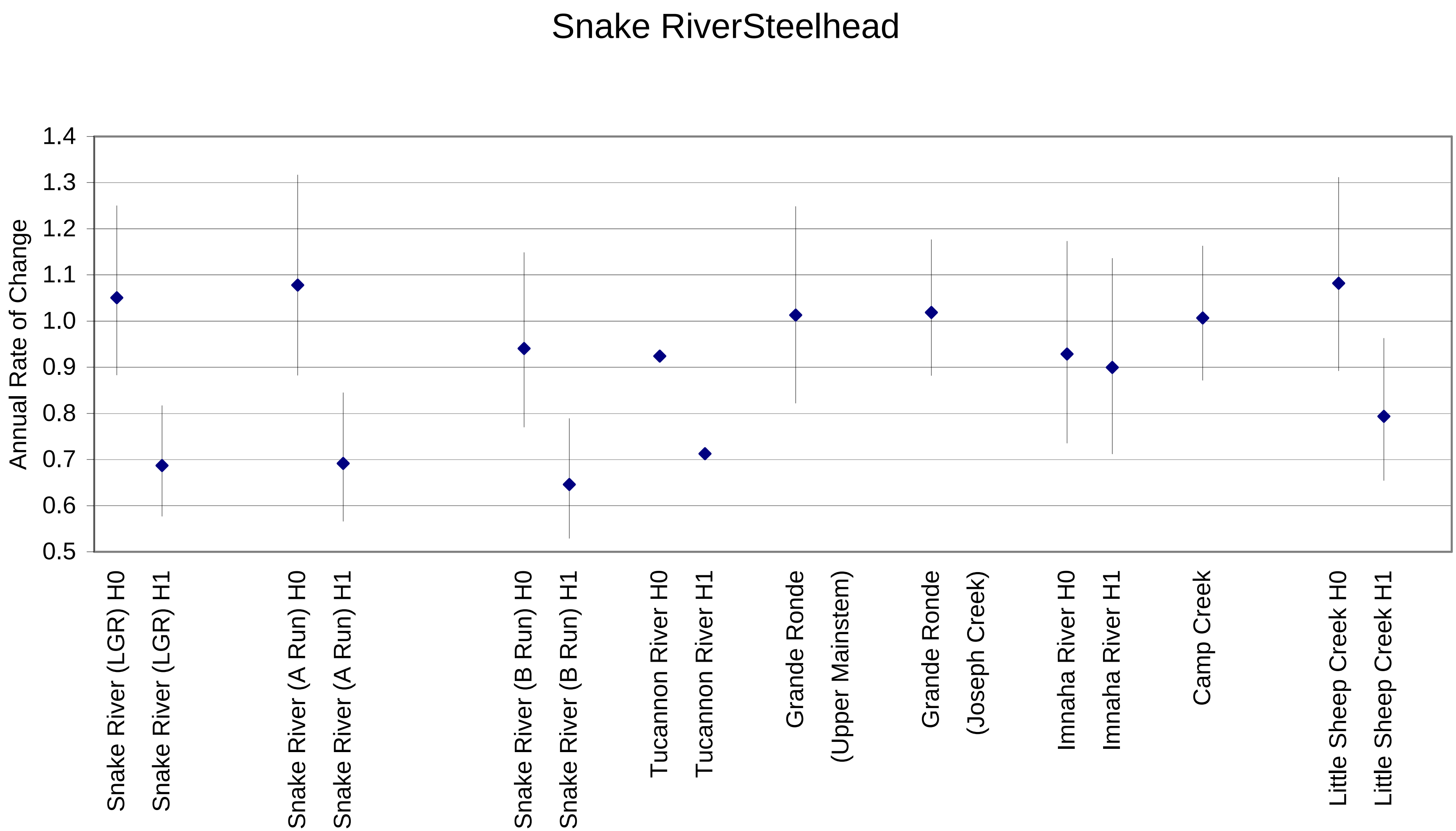


Figure B.2.1.8. Short-term median population growth rate estimates and 95% confidence limits for the Snake River Basin steelhead ESU. Paired estimates are based on calculations where hatchery-origin spawners have reproductive success equal to zero (H0) or equivalent to natural-origin spawners (H1).

B.2.2. UPPER COLUMBIA RIVER STEELHEAD

Primary contributor: Thomas Cooney
(Northwest Fisheries Science Center)

The life-history patterns of Upper Columbia River steelhead are complex. Adults return to the Columbia River in the late summer and early fall; most migrate relatively quickly up the mainstem to their natal tributaries. A portion of the returning run overwinters in the mainstem reservoirs, passing over the upper mid-Columbia dams in April and May of the following year. Spawning occurs in the late spring of the calendar year following entry into the river. Juvenile steelhead spend 1 to 7 years rearing in freshwater before migrating to the ocean. Smolt outmigrations are predominately age 2 and age 3 juveniles. Most adult steelhead return after 1 or 2 years at sea, starting the cycle again.

Estimates of the annual returns of upper Columbia River steelhead populations are based on dam counts. Cycle counts are used to accommodate the prevalent return pattern in up-river summer steelhead (runs enter the Columbia River in late summer and fall, some fish overwinter in mainstem reservoirs—migrating past the upper dams prior to spawning the following spring). Counts over Wells Dam are assumed to be returns originating from natural production and hatchery outplants into the Methow and Okanogan river systems. The total returns to Wells Dam are calculated by adding annual broodstock removals at Wells to the dam counts. The annual estimated return levels above Wells Dam are broken down into hatchery and wild components by applying the ratios observed in the Wells sampling program for run years since 1982.

Harvest rates on upper river steelhead have been cut back substantially from historical levels. Direct commercial harvest of steelhead in non-Indian fisheries was eliminated by legislation in the early 1970s. Incidental impacts in fisheries directed at other species continued in the lower river, but at substantially reduced levels. In the 1970s and early 1980s, recreational fishery impacts in the upper Columbia escalated to very high levels in response to increasing returns augmented by substantial increases in hatchery production. In 1985, steelhead recreational fisheries in this region (and in other Washington tributaries) were changed to mandate release of wild fish. Treaty harvest of summer run steelhead (including returns to the upper Columbia) occurs mainly in mainstem fisheries directed at up-river bright fall chinook.

Hatchery returns predominate the estimated escapement in the Wenatchee, Methow and Okanogan River drainages. The effectiveness of hatchery spawners relative to their natural counterparts is a major uncertainty for both populations. Hatchery effectiveness can be influenced by at least three sets of factors: relative distribution of spawning adults, relative timing of spawning adults, and relative effectiveness of progeny. No direct information is available for the upper Columbia River stocks. Outplanting strategies have varied over the time period the return/spawner data were collected (1976-1994 broodyears). While the return timing into the Columbia River is similar for both wild and hatchery steelhead returning to the upper Columbia, the spawning timing in the hatchery is accelerated. The long-term effects of such acceleration on the spawning timing of returning hatchery-produced adults in nature is not known. We have no direct information on relative fitness of upper Columbia River steelhead progeny with at least one parent of hatchery origin.

B.2.2.1. Summary of Previous BRT Conclusions

The 1998 steelhead status review identified a number of concerns for the Upper Columbia River Steelhead ESU: "While the total abundance of populations within this ESU has been relatively stable or increasing, it appears to be occurring only because of major hatchery supplementation programs. Estimates of the proportion of hatchery fish in spawning escapement are 65% (Wenatchee River) and 81% (Methow and Okanogan Rivers). The major concern for this ESU is the clear failure of natural stocks to replace themselves. The BRT members are also strongly concerned about the problems of genetic homogenization due to hatchery supplementation...apparent high harvest rates on steelhead smolts in rainbow trout fisheries and the degradation of freshwater habitats within the region, especially the effects of grazing, irrigation diversions and hydroelectric Dams." The BRT also identified two major areas of uncertainty; relationship between anadromous and resident forms, and the genetic heritage of naturally spawning fish within this ESU.

B.2.2.2. New Data and Updated Analyses

Population definitions and criteria

An initial set of population definitions for the Upper Columbia River steelhead ESU along with basic criteria for evaluating the status of each population were developed using the Viable Salmonid Population (VSP) guidelines described in McElhany (2000). The definitions and criteria are described in Ford et al. (2000) and have been used in the development and review of Mid-Columbia PUD plans and the FCRPS Biological Opinion. The interim definitions and criteria are being reviewed as recommendations by the Interior Columbia Technical Recovery Team. Briefly, the joint technical team recommended that the Wenatchee River, the Entiat River and the Methow River be considered as separate populations within the Upper Columbia River Steelhead ESU. The Okanogan River may have supported a fourth population; the committee deferred a decision on the Okanogan to the Technical Recovery Team. Abundance, productivity and spatial structure criteria for each of the populations in the ESU were developed and are described in Ford et al. (2001).

Current abundance

Returns of both hatchery and naturally produced steelhead to the upper Columbia River have increased in recent years. Priest Rapids Dam is below Upper Columbia River steelhead ESU production areas. The average 1997-2001 return counted through the Priest Rapids fish ladder was approximately 12,900 steelhead. The average for the previous 5 years (1992-1996) was 7,800 fish.

Total returns to the upper Columbia River continue to be predominately hatchery-origin fish. The natural-origin percentage of the run over Priest Rapids increased to over 25% in the 1980s, then dropped to less than 10% by the mid-1990s. The median percent of natural-origin for 1997-2001 was 17%. Abundance estimates of returning naturally produced Upper Columbia River steelhead have been based on extrapolations from mainstem dam counts and associated sampling information (e.g. hatchery/wild fraction, age composition). The natural component of the annual steelhead run over Priest Rapids increased from an average of 1,040 (1992-1996) to 2,200 (1997-2001).

The estimate of the combined natural steelhead return to the Wenatchee and Entiat rivers increased to a geometric mean of approximately 900 for the 1996-2001 period. The average percentage natural dropped from 35% to 29% for the recent 5-year period. In terms of natural production, recent production levels remain well below the interim recovery levels developed for these populations (Table B.2.2.1, Figure B.2.2.1).

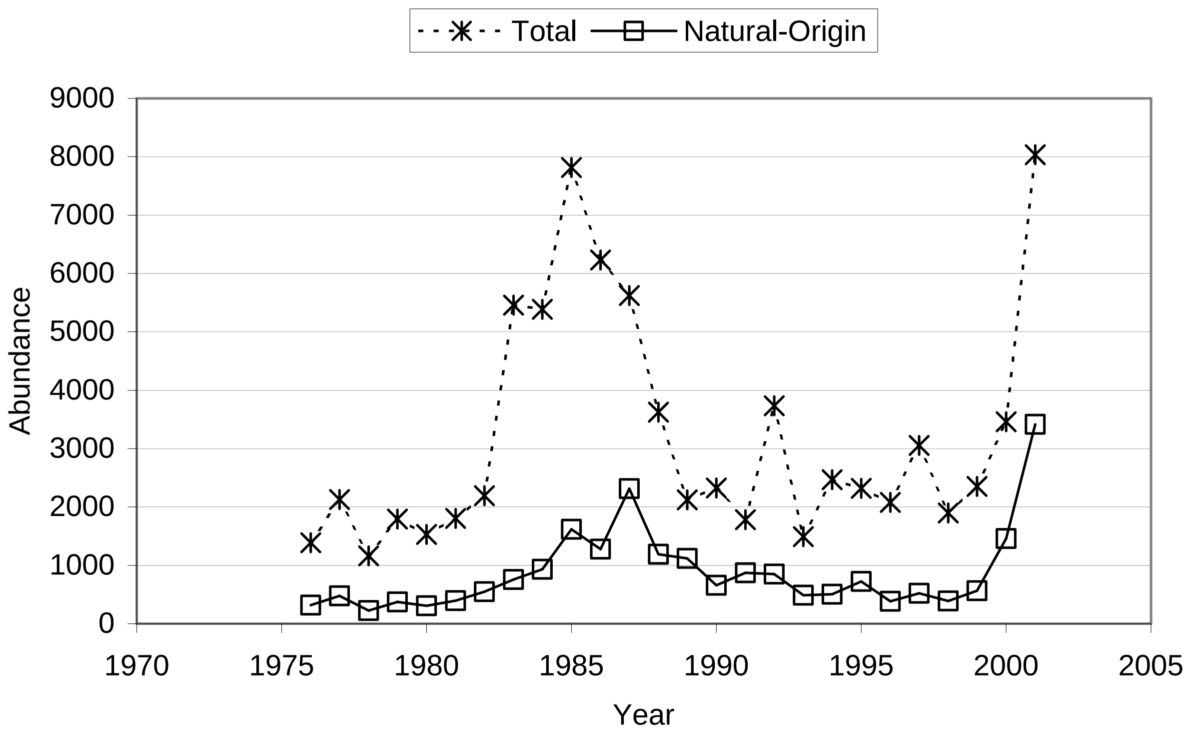


Figure B.2.2.1. Wenatchee/Entiat Rivers steelhead—estimated annual spawner escapements. Cooney, 2001. 1999-2001 data from WDFW.

The Methow River steelhead population is the primary natural production area above Wells Dam. The 1997-2001 geometric mean of natural returns over Wells Dam was 358, lower than the geometric mean return prior to the 1998 status review (Table B.2.2.1, Figure B.2.2.2). The most recent return reported in the data series, 1,380 naturally produced steelhead in 2001, was the highest single annual return in the 25-year data series. Hatchery returns continue to dominate the run over Wells Dam. The average percent of wild origin dropped to 9% for 1996-2001 compared to 19% for the period prior to the previous status review.

Table B.2.2.1. Upper Columbia River steelhead. Summary of current abundance and trend information relative to previous BRT status review. Interim targets from Ford et al. (2001).

Population	5-year mean % natural origin	Recent 5-year geometric mean			Short-term Trend (%/yr)		Interim Target	Current vs. Target
		Total	Natural					
		Mean (Range)	Current	Previous	Current	Previous		
Wenatchee/ Entiat	29 (35*)	3,279 (1,899-8,036)	894	800	+6.5	+2.6	3,000	30%
Methow/ Okanogan	9 (19*)	3,714 (1,879-12,801)	358	450	+13.8	-12.0	2,500	14%

* estimates from previous status review

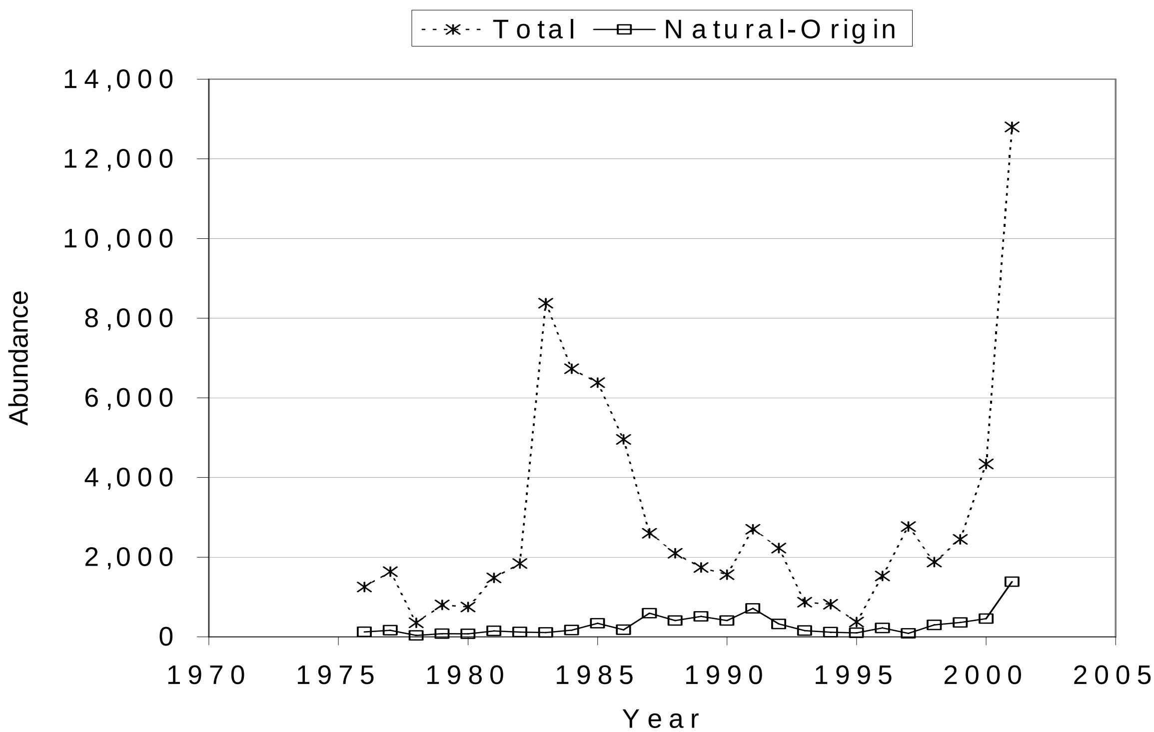


Figure B.2.2.2. Methow River steelhead—estimated annual spawner escapements. Cooney 2001. 1999-2001 data from WDFW.

The analyses described above relied on the 1976-2001 abundance data set. The starting date for that series is set by the advent of counting at Wells Dam (allowed for separate estimates of run strength to the Methow/Okanogan rivers and the Wenatchee/Entiat rivers). The median run (almost all natural origin) from 1933-1954 was approximately 2,300.

Current productivity

Natural returns have increased in recent years for both stock groupings (Table B.2.2.2). Population growth rates, expressed as λ calculated using the running sum method, are substantially influenced by assumptions regarding the relative effectiveness of hatchery spawners. The same key factor must be considered in analyzing return-per-spawner data sets. The relative contribution of returning steelhead of hatchery origin to natural spawning is not clearly understood. There may be timing and spatial differences in the distribution of hatchery and wild origin spawners that affect production of juveniles. Eggs and subsequent juveniles, from natural spawning, involving hatchery-origin fish may survival at a differential rate relative to spawning of natural-origin adults.

Both short-term (1990-present) and long-term (1976-present) estimates of λ are positive under the assumption that hatchery fish have not contributed to natural production in recent years. λ estimates under the assumption that hatchery fish contributed at the same level as wild fish to natural production are substantially lower—under this scenario natural production is consistently and substantially below the total number (hatchery plus natural origin) of spawners in any given year. This result is consistent with those of McClure et al. (2003) and those in the 2000 FCRPS Biological Opinion (NMFS 2000), in which lambda was estimated from the ESU-level time series for the time period 1980-2000. Although the total spawners have an apparent population growth rate of 1.00 (with relatively high variability), this growth rate is lowered to 0.69 if hatchery fish contributed to subsequent generations at the same rate that wild fish do. Clearly, determining the actual contribution of hatchery fish will be an important element in determining the true status of this ESU.

Return-per-spawner patterns for the two steelhead production areas are also substantially influenced by assumptions regarding the relative effectiveness of hatchery-origin spawners (Figures B.2.2.3 and B.2.2.4). Under the assumption that hatchery and wild spawners are both contributing to the subsequent generation of natural returns, return-per-spawner levels have been

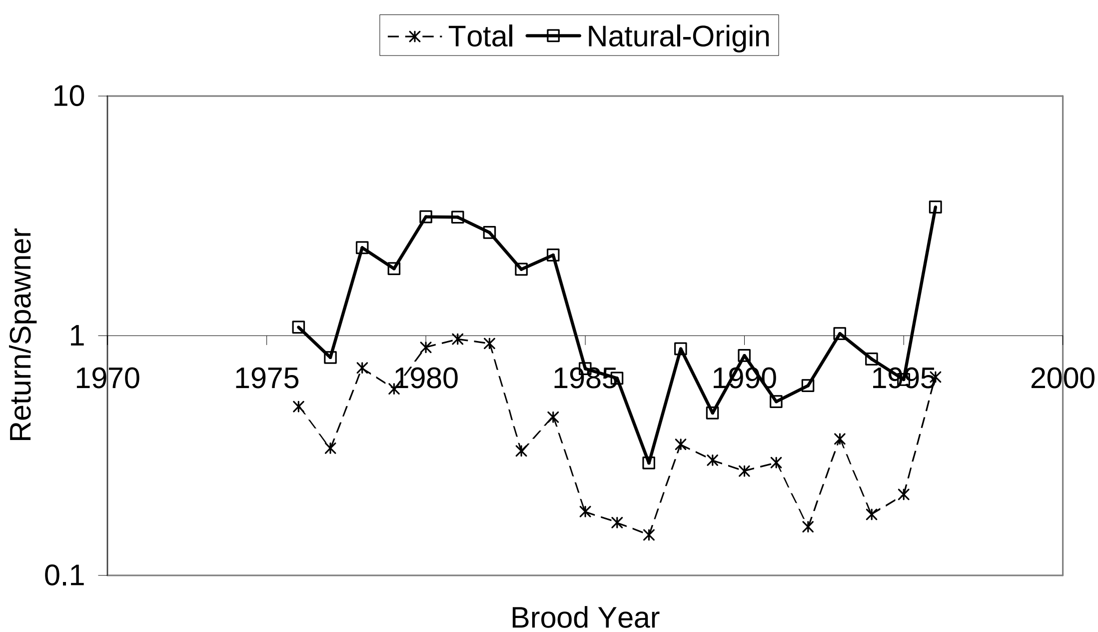


Figure B.2.2.3. Wenatchee/Entiat River steelhead—return-per-spawner vs. broodyear spawning escapement.

Table B.2.2.2: Upper Columbia River steelhead population growth rate analysis. Summary of available trend data sets, results of calculating annual population growth rates (λ: geomean, probability geomean less than 1.0) Long-term = the length of the available data series, Short term = 1990 -2001 or most recent year. Population growth rates calculated for two hatchery effectiveness (HF) assumptions: HF = 0.0 hatchery fish available to spawn do not contribute to natural production; HF = 1.0 hatchery returns available to spawn contribute to broodyear natural production at the same rate as natural-origin spawners. Methods: DC – Dam counts.

Upper Columbia River Steelhead	Series Length	Method	% wild 1987-1996	% wild 1997-2001	1997-2001 geomean	HF	Long-term λ	Prob. λ<1	Short-term λ	Prob. λ<1
Wenatchee/Entiat	1976-2001	DC	0.33	0.29	894	0 1	1.067 0.733	0.112 1.000	1.093 0.753	0.219 0.987
Above Wells Dam	1976-2001	DC	0.17	0.085	358	0 1	1.086 0.579	0.088 1.000	1.277 0.565	0.357 1.000
Methow River	1976-2001	DC	0.21	0.11	358	0 1	1.086 0.589	0.088 1.000	1.277 0.621	0.357 1.000

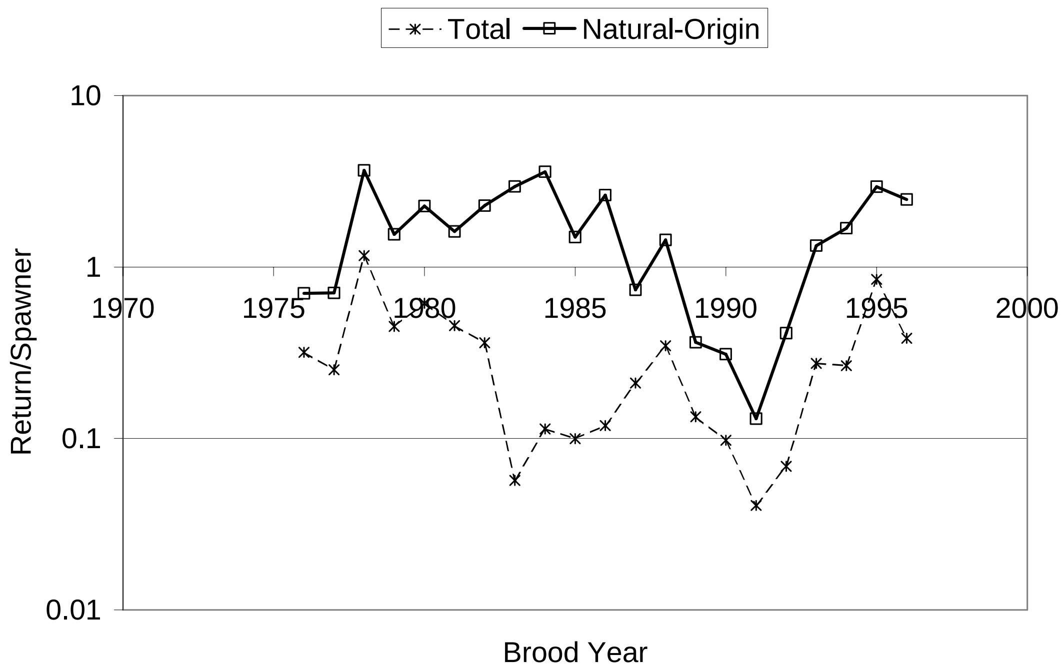


Figure B.2.2.3. Methow River steelhead—return-per-spawner vs. broodyear spawning escapement.

consistently below 1.0 since 1976. Under this scenario natural production would be expected to decline rapidly in the absence of hatchery spawners. Under the assumption that hatchery fish returning to the upper Columbia River do not contribute to natural production, return-per-spawner levels were above one until the late 1980s. Return-per-spawner estimates subsequently dropped below replacement (1.0) and remained low until the most recent broodyear with measured returns—1996. The actual contribution of hatchery returns to natural spawning remains a key uncertainty for upper Columbia River steelhead. This information need is in addition to any considerations for long-term genetic impacts of high hatchery contributions to natural spawning.

Resident *O. mykiss* considerations

This section summarizes available information on resident *O. mykiss* populations within the ESU. Table B.2.2.3 and Appendix B.5.1 provide a broad overview of the distribution of Case 1, 2, and 3 resident populations within the ESU. See the section on Resident Fish in the Introduction section to the main body of this report for an explanation of the three cases and their relevance to ESU determinations. The section on Resident Fish in section B.1 of this steelhead report discusses how resident fish are considered in risk analyses.

Resident *O. mykiss* are relatively abundant in upper Columbia River tributaries currently accessible to steelhead as well as in upriver tributaries blocked off to anadromous access by Chief Joseph and Grand Coulee dams (Kostow 2003 draft). USFWS biologists surveyed the abundance of trout and steelhead juveniles in the Wenatchee, Entiat, and Methow River drainages in the mid 1980s (Mullan 1992). Adult trout (defined as trout > 20 cm) were found in surveys in all basins. Juvenile *O. mykiss* were reported from 94% of the surveys conducted in areas believed to be used by steelhead and resident trout (Kostow 2003 draft). The results also supported the hypothesis that resident *O. mykiss* are more abundant in tributary/mainstem areas above the general areas used by steelhead for rearing.

The original status review did not formally evaluate the current ESU status of resident populations above Chief Joseph Dam, nor did it formally consider whether *O. mykiss* in upper Columbia River tributaries historically were in the same ESU as populations in the Wenatchee, Entiat, Methow, and Okanogan Rivers. Kostow (2003) reports that biologists who are familiar with the areas above Chief Joseph Dam believe that *O. mykiss* are present in significant numbers. Several of the tributaries above Chief Joseph Dam have been blocked off by dams, and introductions of exotic gamefish and trout species have been widespread. We are not aware of specific information relevant to the ESU status of Case 3 resident populations above dams in the Okanogan or Spokane Rivers, or above Chief Joseph and Grand Coulee Dams on the mainstem Columbia River. *O. mykiss,* believed to be native populations, are present in a number of tributaries draining into Lake Roosevelt (Kostow 2003). Mullan (1992) hypothesized that the native trout populations above Chief Joseph Dam effectively preserved native steelhead lineages present before the construction of the mainstem impassable dams. Knudsen et al (2002) concluded that native resident (Case 2) populations persist in some Kootenai River tributaries, in spite of extensive stocking by non-native rainbow trout.

Table B.2.2.3. Distribution of *O. mykiss* trout by category relative to the Upper Columbia River steelhead ESU. Only major barriers are noted; numerous small barriers, both natural and artificial, also exist. Many other natural barriers are present but have *O. clarki* trout, rather than *O. mykiss* trout, above them. *O. mykiss* trout distribution in areas of sympatry with steelhead may be restricted in some areas if native *O. clarki* trout are also in the basin. The generalized listing of basins and subbasins does not imply that these constitute single trout populations or that trout distribution is continuous throughout the areas listed. Detailed trout distribution is usually unknown and actual demographically independent trout populations have not been described. All current trout distributions are decreased from historical distributions. In particular many mainstem and lower basin tributary are no longer used but probably were historically. Many current trout populations are only in upper basins and are highly fragmented.

ESU	Category 1 Trout Populations (Sympatric)	Category 2 Trout Populations (Major Natural Barriers)	Category 3 Trout Populations (Major Artificial Barriers)
Upper Columbia River steelhead	Potentially all areas that are/were used by steelhead Wenatchee Lower Entiat Methow Okanogan	Upper Entiat Upper Kootenay Okanogan: Enloe Falls? Methow: Chewuch? Lost	Trout distributions currently more restricted than historically Okanogan Basin: Conconully Dam Enloe Dam? Chief Joseph Dam Lower Spokane to Post Falls Sanpoil Several small tributaries Lower Pend Oreille to Z-Canyon Columbia headwaters in Canada

B.2.2.3. New Hatchery Information

Hatchery considerations

Hatchery production averaged approximately 300,000 smolts/year in the 1960s, 425,000 in the 1970s, 790,000 in the 1980s, and more than 800,000 in the 1990s (including releases exceeding 1.0 million). Current mitigation/supplementation targets are to use locally obtained returning adults for programs. The objective for the Wenatchee is to release 400,000 smolts per year using broodstock collected from run-of-the-river fish in the Wenatchee River (main collection point is Dryden Dam). Broodstock collected at Wells Dam are used for outplanting in the Methow (380,000 target release), and the Okanogan (100,000 target release). The Entiat basin has been designated as a natural production 'reference' drainage—

no hatchery outplanting. Presently, there exist no monitoring programs in place to directly estimate natural production of steelhead in the Entiat. Categorizations of Upper Columbia River steelhead hatchery stocks (SSHAG 2003) can be found in Appendix B.5.3.

Table B.2.2.4. Hatchery releases of steelhead in the Upper Columbia River basin, organized by major steelhead production areas and broodstock of the release. Averages calculated by time period to facilitate comparison of release levels since the last BRT review with previous levels.

Basin	**Stock**	**Average releases per year**		
		1985 - 1989	**1990 - 1994**	**1995 - 2001**
Mainstem Columbia	Ringold	220,421	144,303	-
	Wells	27,757	26,204	202,269
	Skamania	-	35,130	70,523
	Wenatchee River	-	-	500
	Mainstem Total	177,270	146,883	273,292
Entiat	Wells	43,863	43,247	18,098
	Wenatchee River	-	-	12,465
	Entiat Total	43,863	43,247	30,564
Methow	Wells	439,926	428,894	418,227
Okanogan	Wells	133,198	123,972	119,996
Wenatchee	Leavenworth	62,376	95,631	23,960
	Ringold	113,225	-	-
	Wells	121,272	351,735	176,643
	Wenatchee River	81,072	-	106,554
	Wenatchee Total	377,945	447,366	307,158
ESU Total	All Stocks	1,243,110	1,249,116	1,149,239

B.2.3 MIDDLE COLUMBIA RIVER STEELHEAD

Primary contributor: Thomas Cooney
(Northwest Fisheries Science Center)

The Middle Columbia River Steelhead ESU includes steelhead populations in Oregon and Washington drainages upstream of the Hood and Wind river systems to and including the Yakima River. The Snake River is not included in this ESU. Major drainages in this ESU are the Deschutes, John Day, Umatilla, Walla-Walla, Yakima, and Klickitat river systems. Almost all steelhead populations within this ESU are summer-run fish, the exceptions being winter-run components returning to the Klickitat, and Fifteen Mile Creek watersheds. Most of the populations within this ESU are characterized by a balance between 1- and 2-year-old smolt outmigrants. Adults return after 1 or 2 years at sea.

Hatchery facilities are located in a number of drainages within the geographic area of this ESU, although there are also subbasins with little or no direct hatchery influence. The John Day River system, for example, has not been outplanted with hatchery steelhead. Similarly, hatchery production of steelhead in theYakima River system was relatively limited historically and has been phased out since the early 1990s. However, the Umatilla and the Deschutes river systems each have ongoing hatchery production programs based on locally derived broodstocks. Moreover, straying from out-of-basin production programs into the Deschutes River has been identified as a chronic occurrence. The Walla Walla River (three locations in Washington sections) historically received production releases of Lyons Ferry stock summer steelhead from the Lower Snake River Compensation Program (LSRCP). Mill Creek releases were halted after 1998 due to concerns associated with the then pending listing of Mid-Columbia River steelhead under the ESA. A new endemic broodstock is under development for the Touchet River release site (beginning with the 1999/2000 return year). Production levels at the Touchet and Walla Walla River release site have been reduced in recent years (WDFW comments to BRT).

Blockages have prevented access to sizable steelhead production areas in the Deschutes River and the White Salmon River. In the Deschutes River, Pelton Dam blocks access to upstream habitat historically used by steelhead. Conduit Dam, constructed in 1913, blocked access to all but 2-3 miles of habitat suitable for steelhead production in the Big White Salmon River (Rawding 2001). Substantial populations of resident trout exist in both areas.

B.2.3.1 Summary of Previous BRT Conclusions

The previous reviews (BRT 1998; BRT 1999) identified several concerns including relatively low spawning levels in those streams for which information was available, a preponderance of negative trends (10 out of 14), and the widespread presence of hatchery fish throughout the ESU. The 1999 BRT review specifically identified "...the serious declines in abundance in the John Day River Basin…" as a point of concern given that the John Day system had supported large populations of naturally spawning steelhead in the recent past. Concerns were also expressed about the low abundance of returns to the Yakima River system relative to historical levels "...with the majority of production coming from a single stream (Satus Creek)." The sharp decline in returns to the Deschutes River system was also identified as a concern.

The 1999 BRT review identified increases of stray steelhead into the Deschutes River as a "major source of concern." The review acknowledged that initial results from radio tagging studies indicated that a substantial proportion of steelhead entering the Deschutes migrated out of the system prior to spawning.

The previous BRT review identified a set of habitat problems affecting basins within this ESU. High summer and low winter temperatures are characteristic of production or migration reaches associated with populations within this ESU. Water withdrawals have seriously reduced flow levels in several Mid-Columbia drainages, including sections of the Yakima, Walla-Walla, Umatilla, and Deschutes rivers. Riparian vegetation and instream structure has been degraded in many areas—the previous BRT report states that "(O)f the stream segments inventoried within this ESU, riparian restoration is needed for between 37% and 84% of the river bank in various basins."

B.2.3.2 New Data and Updated Analyses

Abundance

With some exceptions, the recent 5-year average (geometric mean) abundance for natural steelhead within this ESU was higher than levels reported in the last status review (BRT 1999). Information on recent returns in comparison to return levels reported in previous status reviews is summarized in Table B.2.3.1 and depicted in Figures B.2.3.1-B.2.3.10. Returns to the Yakima River, the Deschutes River, and to sections of the John Day River system were up substantially in comparison to 1992-1997. Yakima River returns are still substantially below interim target levels and estimated historical return levels, with the majority of spawning occurring in one tributary, Satus Creek (Berg 2001). The recent 5-year geometric mean return of the natural-origin component of the Deschutes River run has exceeded interim target levels. Recent 5-year geometric mean annual returns to the John Day basin are generally below the corresponding mean returns reported in the previous status reviews. However, each of the major production areas in the John Day system has shown upward trends since the 1999 return year.

Recent year (1999-2001) redds-per-mile estimates of winter steelhead escapement in Fifteen Mile Creek were also up substantially relative to the annual levels in the early 1990s. Returns to the Touchet River are lower that the previous 5-year average. Trend or count information for the Klickitat River winter steelhead run are not available but current return levels are believed to be below interim target level.

Productivity

Short-term trends in major production areas were positive for seven of the 12 areas (Table B.2.3.1). The median annual rate of change in abundance since 1990 was +2.5%, individual trend estimates ranged from -7.9% to +11%. The same basic pattern was reflected in λ estimates for the production areas. The median short-term (1990-2001) annual

Table B.2.3.1. Summary of recent 5-year average (geometric mean) population abundance and trend estimates in comparison to estimates included in previous BRT review (BRT 1999). Estimates from previous status reviews in brackets. NR = no releases.

Population	**5-year mean % natural origin**[+]	**Recent 5-year geometric mean**			**Short-term Trend (%/yr)**		**Interim Target**	**Current vs. Target**
		Total	**Natural**					
		Mean (Range)	**Current**	**Previous**	**Current**	**Previous**		
Klickitat River	?	155 Redds (97 – 261)			+14.6	-9.2	3,600 sum+win	below target
Yakima River *	97 [95]	1,801 (1,058– 4,061)	1,747	800	+10.0	+14.0	8,900	20%
Fifteenmile Creek *	100 [100?]	2.87 RPM (1.3 – 6.0)			+7.8	-5.4	900	
Deschutes River	38 [50]	13,455 (10026– 21457)	5,113	3,000	+11.2	+2.6	5,400	95%
John Day Upper Mainstem	96 [100]	2,122 (926 – 4,168)	2,037		-1.7	-15.2	2,000	102%
John Day Lower Mainstem	NR	1.40 RPM (0.0-5.4)			-2.5	-15.9	3,200	
John Day Upper N. Fork	NR	2.57 RPM (1.6-5.0)			+9.6	-11.8	2,700	
John Day Lower N. Fork	NR	3.52 RPM (1.5-8.8)			+11.0	-1.2		
John Day Middle Fork	NR	3.70 RPM (1.7-6.2)			-2.7	-13.7	2,700	
John Day S. Fork	NR	2.52 RPM (0.9-8.2)			-0.8	-7.4	600	
Umatilla River	60 [76]	2,486 (1,480– 5,157)	1,492	1,096	+8.6	+0.7	2,300	65%
Touchet R. **	84 [93]	345 (273 – 527)	289	300	-0.5	-2.7	900	32%

* 5-year geometric mean calculated using years 1997–2001
** 5-year geometric mean calculated using only years 1998–2001

Table B.2.3.2 Middle Columbia River Steelhead population growth rate analysis. Summary of available trend data sets, results of calculating annual population growth rates (λ: geomean, probability geomean less than 1.0) Long-term = the length of the available data series, Short term = 1990 -2001 or most recent year. Population growth rates calculated for two hatchery effectiveness (HF) assumptions; HF = 0.0 hatchery fish available to spawn do not contribute to natural production, HF = 1.0 hatchery returns available to spawn contribute to broodyear natural production at the same rate as natural-origin spawners. Methods: DC – Dam counts; RC – redd counts; RPM – redds per mile index; TLC – estimated total live fish on spawning grounds.

	Series Length		**Proportion Wild**			**Geometric**	**Lambda (Mean, Prob. <1.0)**			
Mid-Columbia Steelhead		**Measure**	**1987-96**	**Last 5 yrs**	**Hatchery Effectiveness Assumption**	**Recent**	**Long Term**		**Short Term**	
Yakima River Aggregate	1981-2000	DC		0.942	***HF =0.0*** ***HF=1.0***	**901**	**1.009**	0.456	**1.002**	0.49
Klickitat River	1990-92,96-01	RC	na	na						
Deschutes River	1978-2002	DC	0.4	0.38	***HF =0.0*** ***HF=1.0***	**5566**	**1.022** **0.84**	0.35 0.999	**1.076** **0.816**	0.276 0.964
Warm Springs (above weir)	1980-1999		1	1			**0.942**	0.852	**0.904**	0.792
John Day R. Upper Mainstem	1974-2002	Exp. RC	1 0.986	0.963	***HF =0.0*** ***HF=1.0***	**2256**	**0.975** **0.966**	0.699 0.817	**0.963** **0.935**	0.672 0.789
John Day R. Lower Mainstem	1965-2001	Exp. RC		1			**0.981**	0.85	**1.010**	0.463
John Day R. Upper North Fork	1977-2002	Exp. RC		1			**1.011**	0.412	**1.077**	0.132
John Day R. Lower North Fork	1976-2002	Exp. RC		1			**1.013**	0.43	**1.174**	0.026
John Day R. Middle Fork	1974-2002	Exp. RC		1			**0.966**	0.743	**0.954**	0.655
John Day R. South Fork	1974-2002	Exp. RC		1			**0.967**	0.739	**1.011**	0.459
Umatilla River	1966-2002	DC	0.758	0.674	***HF =0.0*** ***HF=1.0***	**1658**	**1.007** **0.969**	0.399 0.854	**1.070** **0.947**	0.135 0.82
Walla Walla: Touchet River	1987-2001	DC	0.911	0.842	***HF =0.0*** ***HF=1.0***	**290**	**0.961** **0.939**	0.769 0.74	**0.984** **0.959**	0.676 0.666
Walla Walla: Main fork	1993-2000	DC		Data series too short to calculate trends						
Fifteen Mile Cr. (Winter Run)	1966-2001	RPM	na	na		3.48	**0.981**	0.635	**1.129**	0.064

population growth rate estimate was 1.045, assuming that hatchery fish on the spawning grounds did not contribute to natural production, with eight of the 12 indicator trends having a positive growth rate. Assuming that potential hatchery spawners contributed at the same rate as natural-origin spawners resulted in lower estimates of population growth rates. The median short-term λ under the assumption of equal hatchery/natural-origin spawner effectiveness was .967, with six of the 12 indicator trends exhibiting positive growth rates.

Long-term trend estimates were also calculated using the entire length of the data series available for each production area (Table B.2.3.1). The median estimate of long-term trend over the 12 indicator data sets was -2.1% per year (-6.9 to +2.9), with 11 of the 12 being negative. Long-term annual population growth rates (λ) were also negative (Table B.2.3.1). The median long-term λ was .98 under the assumption that hatchery spawners do not contribute to production, and .97 under the assumption that both hatchery and natural-origin spawners contribute equally. These longer trends are consistent with another recent analysis (McClure et al. 2003) of 28 index areas in the Middle-Columbia steelhead ESU over the 1980-2000 time period. In this analysis, the average population growth rate across all streams was 0.96, with only two of the 28 index areas showing a positive trend. [Note that the analyses in McClure et al. 2003 bracket those in the 2000 FCRPS Biological Opinion, which used slightly different assumptions about hatchery fish spawning effectiveness.]

All of the production area trends available for this ESU indicate relatively low escapement levels in the 1990s. For some of the data sets, earlier annual escapements were relatively high compared to the stream miles available for spawning and rearing. In those cases, it is reasonable to assume that subsequent production may have been influenced by density-dependent effects. In addition, there is evidence of large fluctuations in marine survival for Columbia River and Oregon coastal steelhead stocks (Cooney 2000, Chilcote 2001). Spawner return data sets for Mid-Columbia production areas are of relatively short duration. As a result of these considerations, projections based on simple population growth rate trends or on stock recruit relationships derived by fitting recent year spawner return data should be interpreted with caution.

Resident *O. mykiss* considerations

This section summarizes available information on resident *O. mykiss* populations within the ESU. Table B.2.3.3 and Appendix B.5.1 provide a broad overview of the distribution of Case 1, 2, and 3 resident populations within the ESU. See the section on Resident Fish in the Introduction section to the main body of this report for an explanation of the three cases and their relevance to ESU determinations. The section on Resident Fish in section B.1 of this steelhead report discusses how resident fish are considered in risk analyses.

Resident *O. mykiss* are sympatric with current and historical anadromous steelhead distribution throughout the Middle Columbia Steelhead ESU (Kostow 2003). Pelton/Round Butte Dam in the Deschutes River system and Condit Dam in the White

Salmon River are the major anadromous blockages within tributaries in this ESU. Irrigation diversions in other tributaries including the Umatilla and Yakima Rivers result in partial blockages or reduce the survival of migrating steelhead.

Lower reaches of most major tributaries in this ESU have been heavily affected by decades of agricultural impacts. The Deschutes River is an exception; its lower tributaries are relatively intact with strong flows of cold water. The resident *O. mykiss* population in the lower Deschutes River is highly productive, supporting some of the largest and most fecund trout in the entire Columbia Basin (Kostow 2003).

Tributaries and mainstem reaches in the upper portions of the Umatilla River, Walla Walla River and the Klickitat River are all relatively intact and support both steelhead and resident O. mykiss populations although there are no specific estimates of abundance for the resident form (Kostow 2003).

Resident *O. mykiss* production varies widely among the tributaries of the relatively large Yakima River system. Access by returning anadromous migrants to the Upper Yakima River drainage was effectively cut off for 18 years by Roza Dam. That area is believed to have been the most productive historical habitat for steelhead. Resident *O. mykiss* currently dominate production above Rosa Dam. Two lower Yakima tributaries, Satus Creek and Toppenish Creek, support most of the current steelhead production from the basin. The absence of 2+ smolts in these tributaries indicates little or no resident production. Steelhead and resident trout are present in the Naches River subbasin.

The John Day River system may have historically supported large populations of resident trout; their redds have been observed during steelhead redd surveys in this system (Kostow 2003). Some proportion of the age 0/age 1 fish counted during juvenile transects may be resident trout, although these redds are not systematically counted.

The mainstem Umatilla River has been heavily impacted by water withdrawals and other agricultural activities. However, headwater reaches are generally intact and have the capacity to support fairly large anadromous and resident *O. mykiss* juvenile production. Abundance estimates of juvenile *O. mykiss* from the upper Umatilla mainstem and tributaries show a high percentage of age 0 and 1 juveniles, while those 2+ and older make up a relatively small proportion of the juvenile sampled. Kostow (2003) concluded that resident adults may still outnumber returning steelhead in the basin.

Studies of relative spawning distributions and timing for steelhead and sympatric resident *O. mykiss* populations have been conducted on the upper Yakima River (Pearsons et al. (1998) and the Deschutes River (Zimmerman and Reeves, 2000). Pearsons et al (1998) concluded that there were substantial overlaps in spawning timing and distribution in the upper Yakima River, with steelhead spawning distributions generally nested within those of resident *O. mykiss*. The Deschutes River study indicated less overlap because of differences in microhabitat use by the two forms. In a previous study Zimmerman and Reeves (1996) did document trout and steelhead pairing late in the steelhead spawning period. Kostow (2003) reports observations of possible steelhead resident pairings during spawning on the John Day, Klickitat, Walla-Walla and Umatilla Rivers.

Table B.2.3.3: Distribution of *O. mykiss* trout by category relative to the Middle Columbia steelhead ESU. Only major barriers are noted; numerous small barriers, both natural and artificial, also exist. Many other natural barriers are present but have *O. clarki* trout, rather than *O. mykiss* trout, above them. *O. mykiss* trout distribution in areas of sympatry with steelhead may be restricted in some areas if native *O. clarki* trout are also in the basin. The generalized listing of basins and subbasins does not imply that these constitute single trout populations or that trout distribution is continuous throughout the areas listed. Detailed trout distribution is usually unknown and actual demographically independent trout populations have not been described. All current trout distributions are decreased from historical distributions. In particular many mainstem and lower basin tributary are no longer used but probably were historically. Many current trout populations are only in upper basins and are highly fragmented.

ESU	**Category 1 Trout Populations (Sympatric)**	**Category 2 Trout Populations (Major Natural Barriers)**	**Category 3 Trout Populations (Major Artificial Barriers)**
Middle Columbia Steelhead	Historically all areas where steelhead are/were present. Trout distributions currently more restricted. Fifteenmile Eightmile Deschutes Klickitat Umatilla: Upper Umatilla John Day: Upper tributaries Walla Walla Upper tributaries Yakima: Upper Yakima Naches Some other small tributaries	All natural barriers upstream of Klickitat and Deschutes Basins: Deschutes: White River Upper Deschutes (Big Falls) Upper NFk Crooked R. John Day: Upper SFk. John Day	Trout distributions currently more restricted than historically Little White Salmon (Conduit Dam) Deschutes (Pelton/Round Butte dams) Metolius Squaw Cr. Crooked River Umatilla (Irrigation dams) Willow Cr. Butter Cr. McKay Cr.

Zimmerman and Reeves (2000) used otolith microchemistry to compare samples of returning adult steelhead to samples taken from resident trout. They concluded that the anadromous steelhead sampled had anadromous mothers and that the resident trout sampled had resident mothers. The study was unable to determine the corresponding contributions of anadromous and resident males to anadromous and resident progeny.

In the Klickitat River basin, a sample of presumed resident fish from above Castille Falls appears to be of native origin (rather than introduced rainbow trout), based on genetic analyses conducted by WDFW (S. Phelps, unpublished data). However, this is a Case 2 population (above a natural barrier) and is also differentiated from anadromous populations within the ESU. Currens (1997) found genetic evidence for substantial isolation between resident fish in Eightmile Creek (a tributary of Fifteenmile Creek) and anadromous fish within the ESU. This is believed to be a Case 1 population—historical contact with anadromous fish and no apparent barrier to migration at present. The genetic profile for the resident fish is consistent with it being a native redband population rather than introduced rainbow trout.

Currens (1997) genetically compared Case 3 resident *O. mykiss* above artificial barriers in McKay Creek and Butter Creek (both tributaries of the Umatilla River) with samples from Umatilla River steelhead. Considerable variation was found among all samples, but the samples from McKay Creek were particularly distinctive. Currens speculated that the McKay Creek population may have been introgressed with non-native hatchery rainbow trout, which have been stocked in the area.

In the Deschutes River basin, Currens et al. (1990) found genetic differences between *O. mykiss* populations from upper and lower Nena Creek and East Fork Foley Creek that were of the same magnitude as differences among different steelhead populations within the basin. The upper and lower reaches of these creeks are separated by natural waterfalls that may or may not serve as barriers to anadromous fish (hence, it is uncertain whether these are Case 1 or Case 3 populations). White River falls is an ancient barrier, and Case 2 resident fish above the falls are genetically quite distinctive (Currens et al. 1990).

In the John Day River, Currens et al. (1987) found that genetic differences between *O. mykiss* from the North and South Forks were larger than differences between presumed steelhead and (Case 1) rainbow trout in the South Fork. Genetic analysis of Yakima River *O. mykiss* (Pearsons et al. 1998) found no significant differences between sympatric resident (Case 1) and anadromous fish, a finding that is consistent with observations of interbreeding between the two forms.

B.2.3.5. New Hatchery Information

Relatively high numbers of hatchery-origin steelhead returning from releases outside of the Deschutes River system continue to enter the Deschutes system. The actual number of out-of-basin-origin hatchery fish that spawn naturally in the Deschutes is not known. Preliminary results from recent radio tracking studies cited in Cramer et al. (2002)

backs up the hypothesis that a significant proportion of hatchery strays entering the Deschutes River are ‘dip-ins,’ fish that migrate out of the system prior to spawning. The estimated escapements to the spawning grounds used in the status review updates already include an adjustment to reflect out-migrating stray hatchery fish. The estimates of spawning escapement into the Deschutes River system depicted in Figure B.2.3.2 assumed that 50% of the estimated number of outside hatchery fish passing over Sherars Falls dropped back down and did not contribute to spawning in the Deschutes River system (Chilcote 2002 spreadsheet analysis). Cramer et al. (2002) identified two other sets of information regarding the potential contribution of hatchery stocks to natural spawning in the Deschutes River. ODFW spawner surveys in Buckhollow, Bakeoven, and Trout creeks indicate a relatively high proportion of wild fish in those major spawning tributaries in recent years, in comparison to the estimated fraction of wild over Sherars Falls (below major mainstem spawning areas). In addition, estimated natural-origin returns to the mainstem/lower tributary roughly track the returns to the Warm Springs River in time, in spite of large differences in estimated hatchery contributions in some years. Additional information is needed to clarify the potential impact of outside hatchery-origin fish to natural production in the system. Categorizations of Middle Columbia River steelhead hatchery stocks (SSHAG 2003) can be found in Appendix B.5.3.

Table B.2.3.4. Steelhead hatchery releases in Middle Columbia River region by major steelhead production areas and release broodstock release. Averages calculated by time period to facilitate comparison of release levels since the last BRT review with previous levels.

Basin	Race	Stock	Average releases per year		
			1985 - 1989	1990 - 1994	1995 - 2001
Mainstem Columbia	Summer	Unknown	4,523	-	-
	Summer	Dworshak B	-	5,440	412
		Mainstem Total	4,523	5,440	412
White Salmon	Summer	Skamania	9,798	18,238	8,641
	Winter	Skamania	12,414	32,615	17,497
	Winter	Elochoman River	-	-	6,428
	Winter	Kalama River	-	-	3,669
	Winter	Beaver Creek	-	-	5,741
		White Salmon Total	22,212	50, 854	41,976
Little White Salmon	Summer	Skamania	0	0	15,395
Klickitat	Summer	Skamania	87,821	96,704	113,616
Deschutes	Summer	Deschutes River	209,443	163,505	168,680
Rock	Winter	Skamania	1,428	5,176	4,083
	Winter	Elochoman River	-	-	1,560
		Rock Creek Total	1,428	5,176	5,644
Umatilla	Summer	Umatilla River	66,730	130,958	142,259
Walla Walla	Summer	Lyons Ferry	191,854	208,632	293,256
	Summer	Wells	116,396	-	-
	Summer	Ringold	-	55,752	-
	Summer	Touchet River	-	-	5,212
		Walla Walla Total	308,251	264,385	298,469
Yakima	Summer	Ringold	21,726	-	-
	Summer	Wells	18,201	-	-
	Summer	Yakima River	112,641	72,039	-
		Yakima Total	152,569	72,039	0
ESU Total		All Stocks	852,978	789,063	786,451

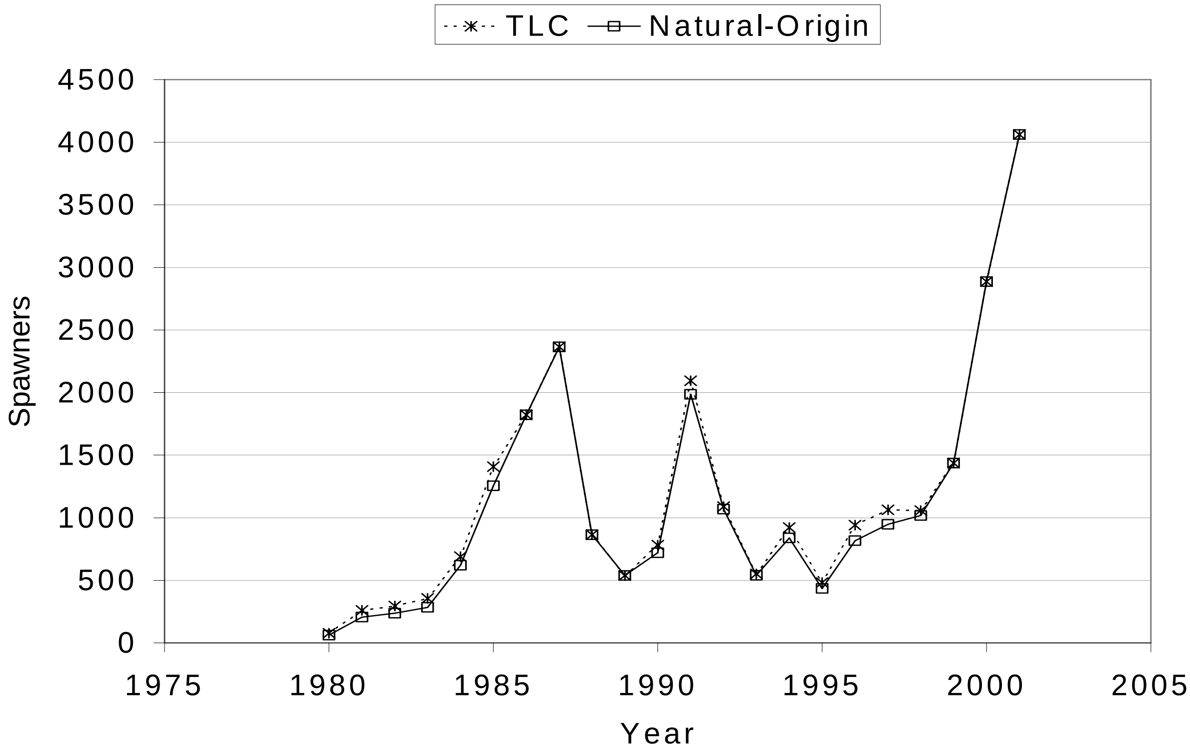


Figure B.2.3.1. Yakima River steelhead spawning escapment estimates. From WDFW database. Based on Prosser Dam count.

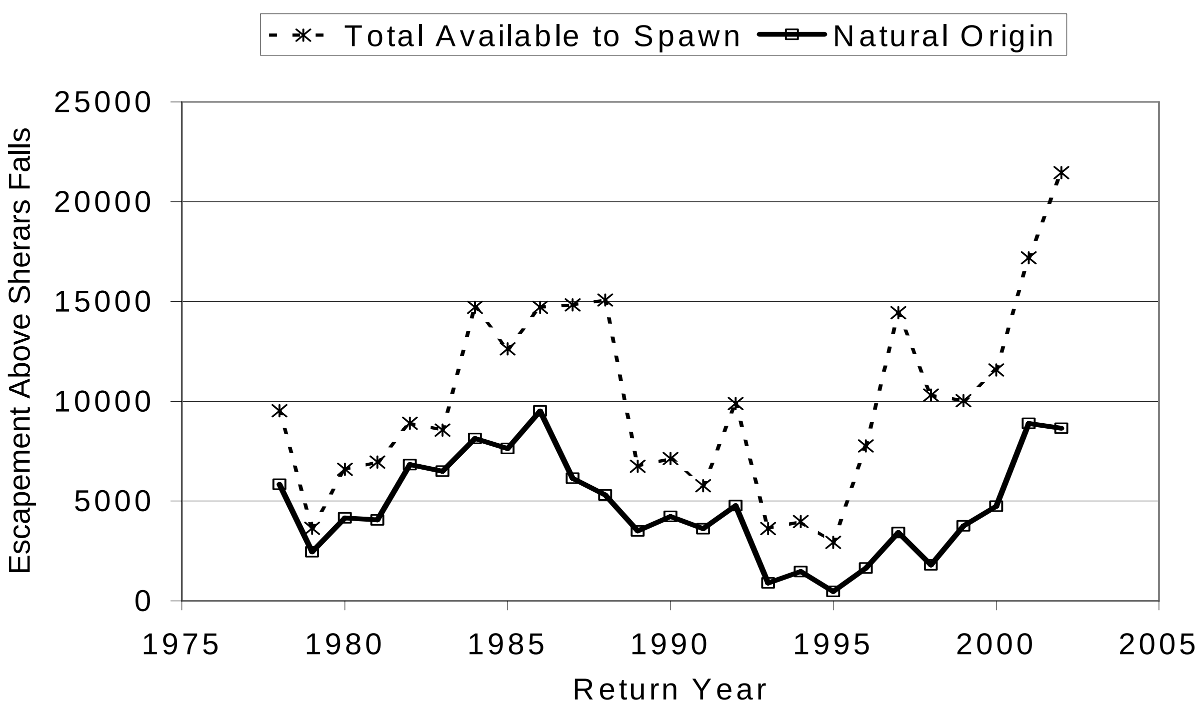


Figure B.2.3.2. Deschutes River steelhead escapement estimates over Sherars Falls. Run size estimates based on ODFW mark/recapture analysis. Hatchery/Wild ratios based on returns to Pelton Ladder and Warm Springs NFH (see Chilcote 2001, 2002).

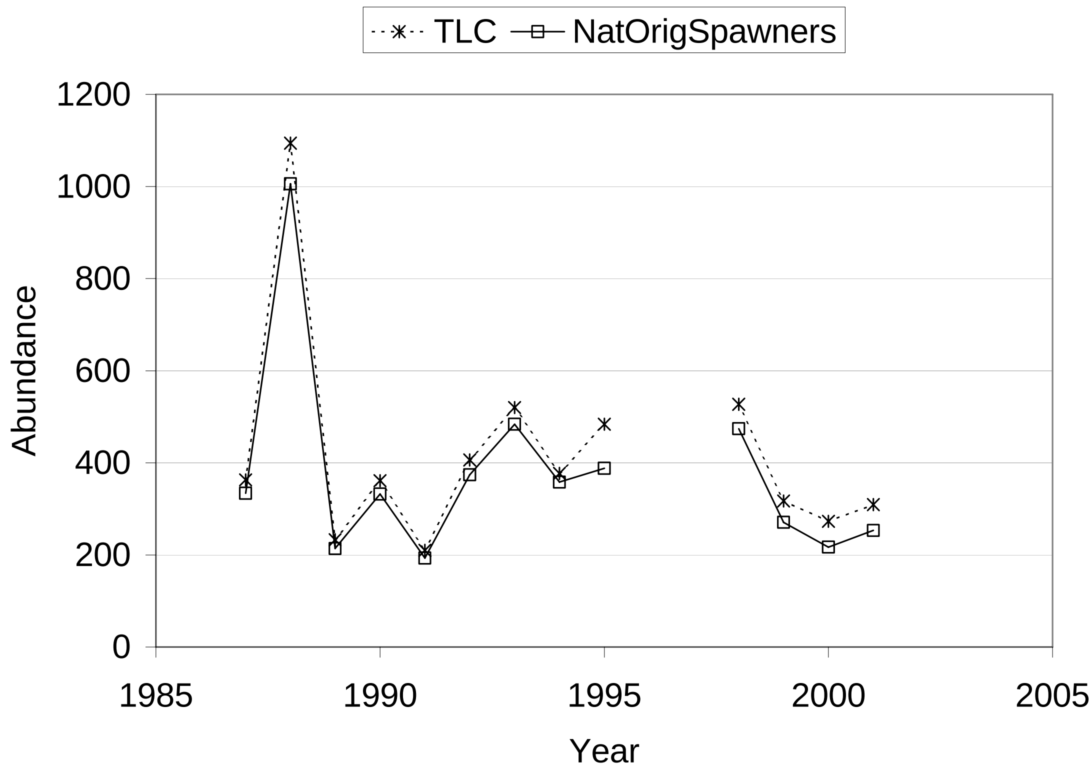


Figure B.2.3.3. Touchet River steelhead escapement estimates. Estimates based on spawning ground surveys upstream of Dayton, WA (James & Scheeler 2001).

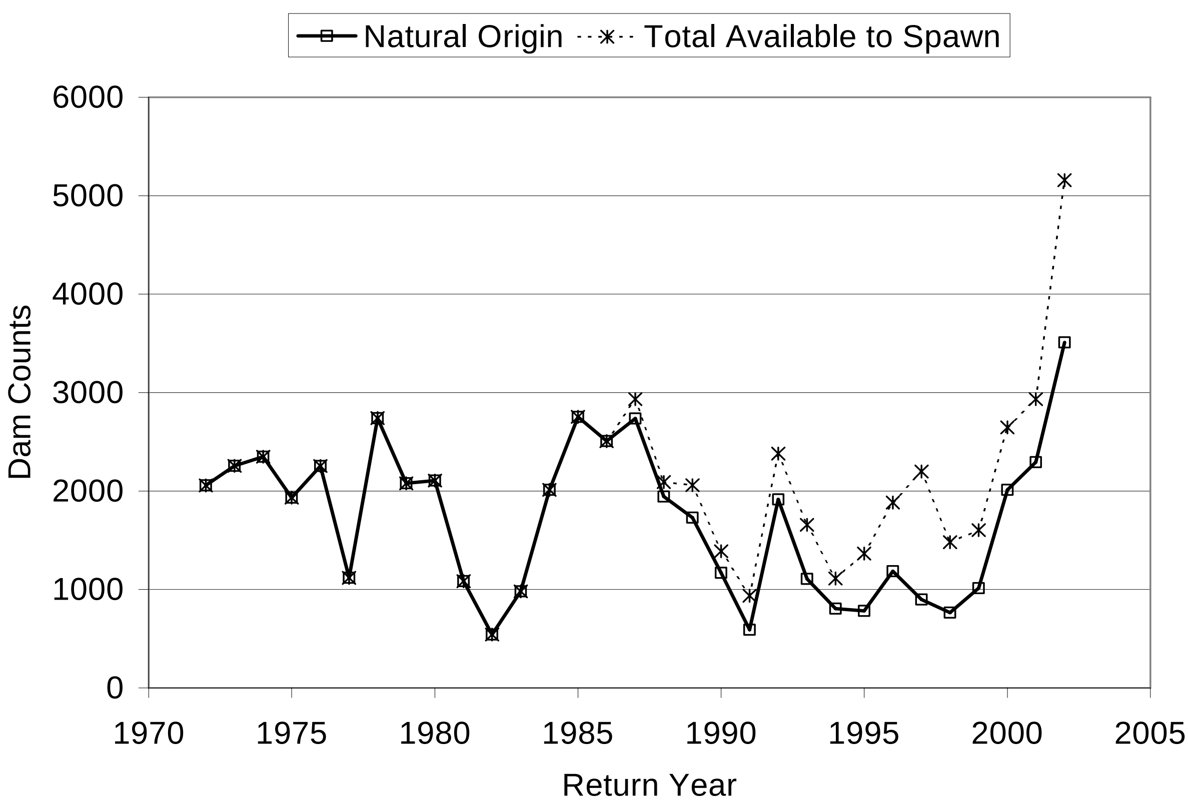


Figure B.2.3.4. Umatilla River steelhead counts at Three Mile Dam (Chilcote 2001).

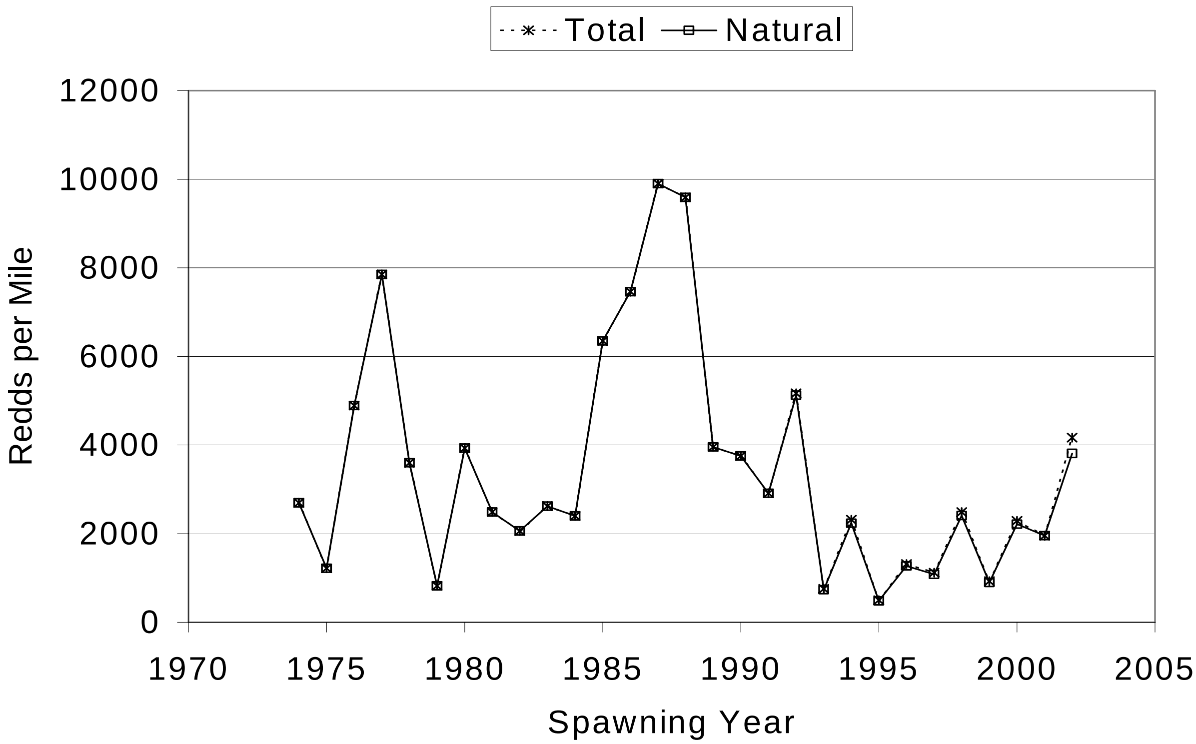


Figure B.2.3.5. Upper John Day steelhead estimates expanded from annual redd counts (Chilcote 2002).

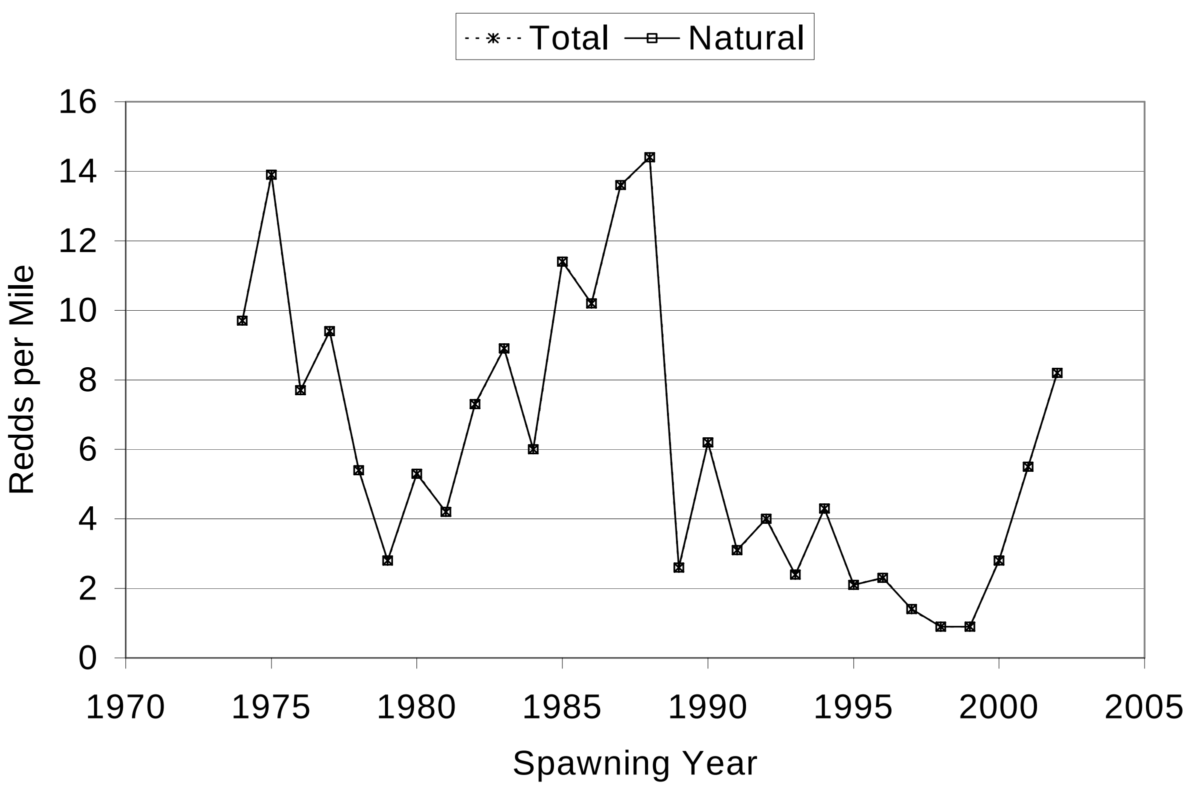


Figure B.2.3.6. South Fork John Day steelhead redds per mile from index areas (Chilcote 2001).

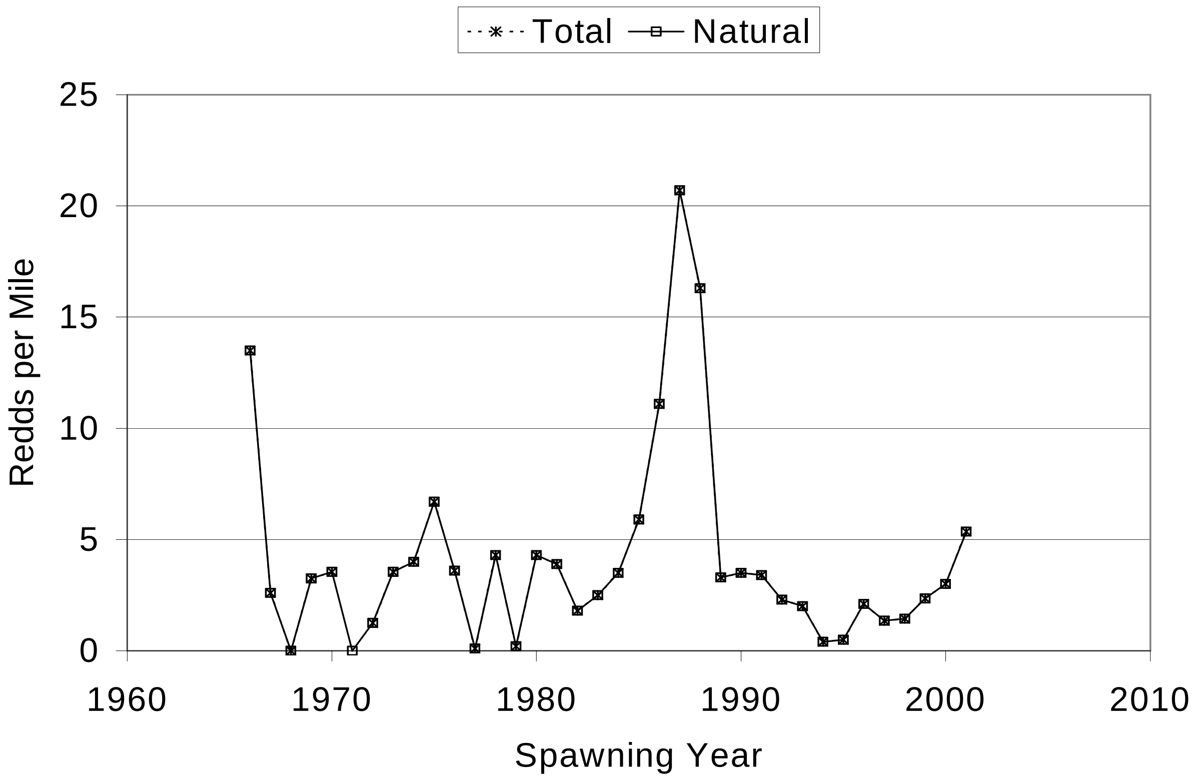


Figure B.2.3.7. Lower Mainstem John Day steelhead redds per mile from index areas (Chilcote 2001).

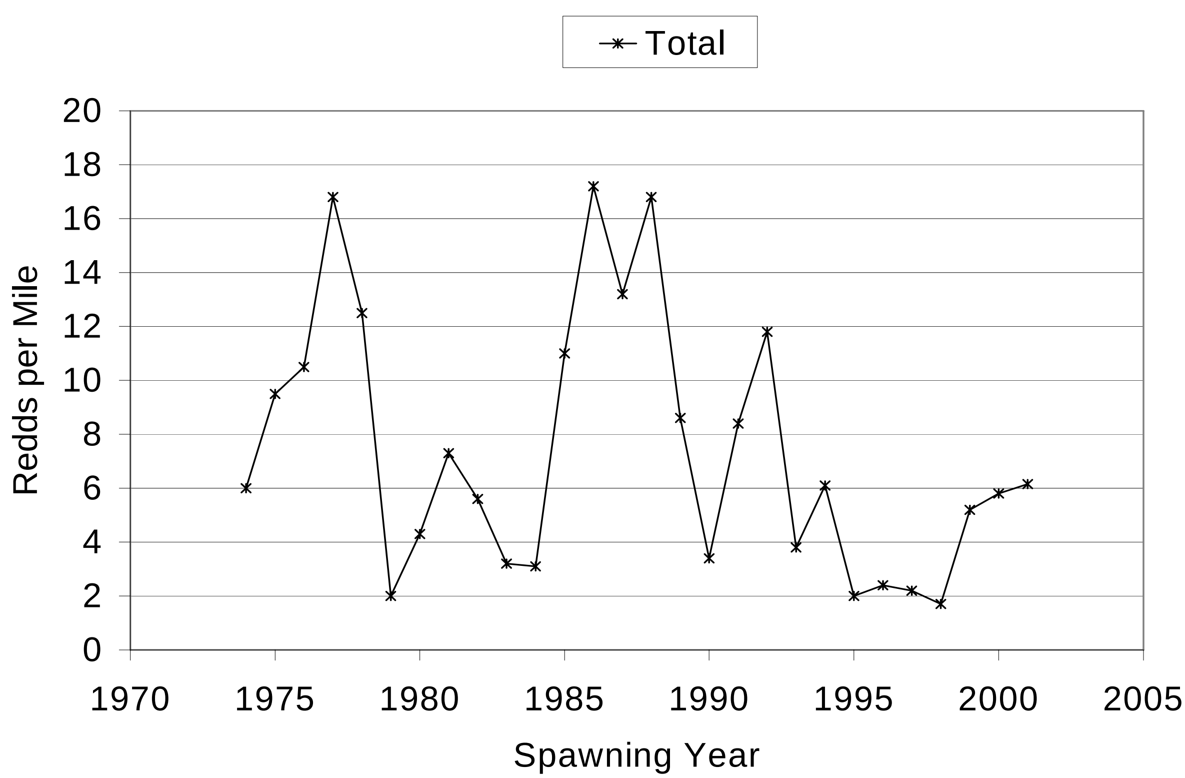


Figure B.2.3.8. Middle Fork John Day steelhead redds per mile from index areas (Chilcote 2001).

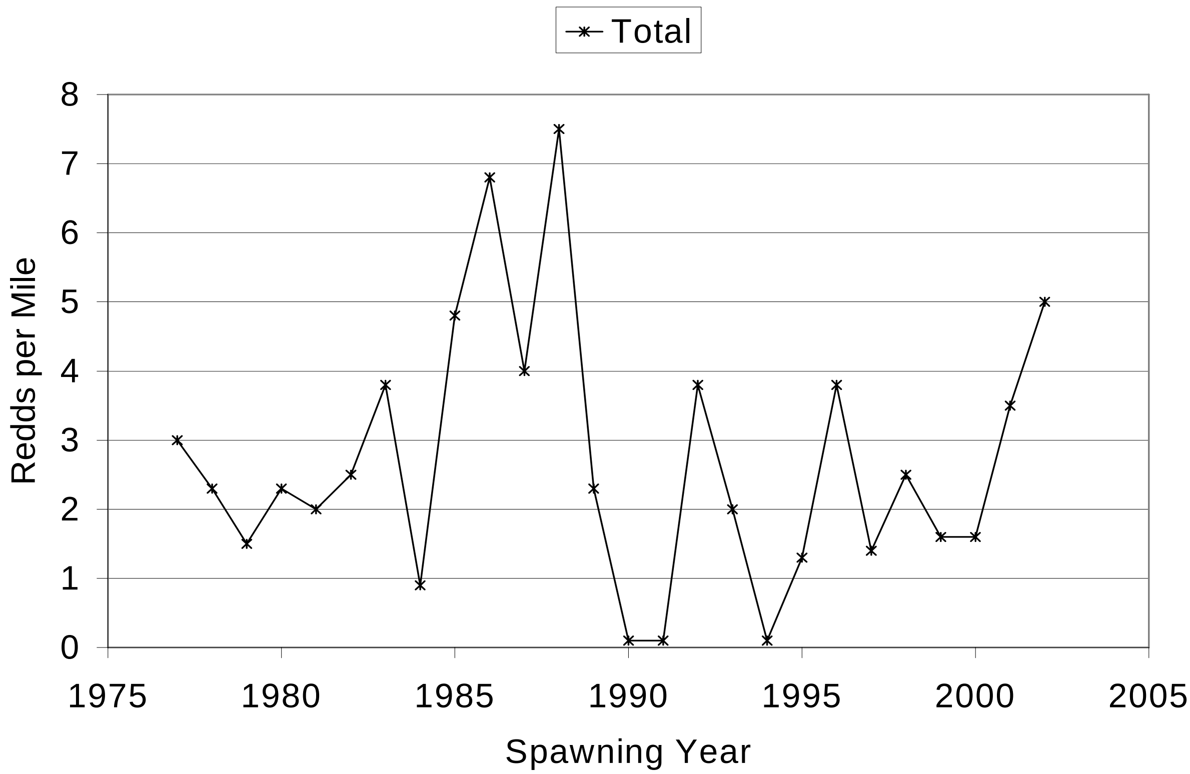


Figure B.2.3.9. Upper North Fork John Day steelhead redds per mile from index areas (Chilcote 2001).

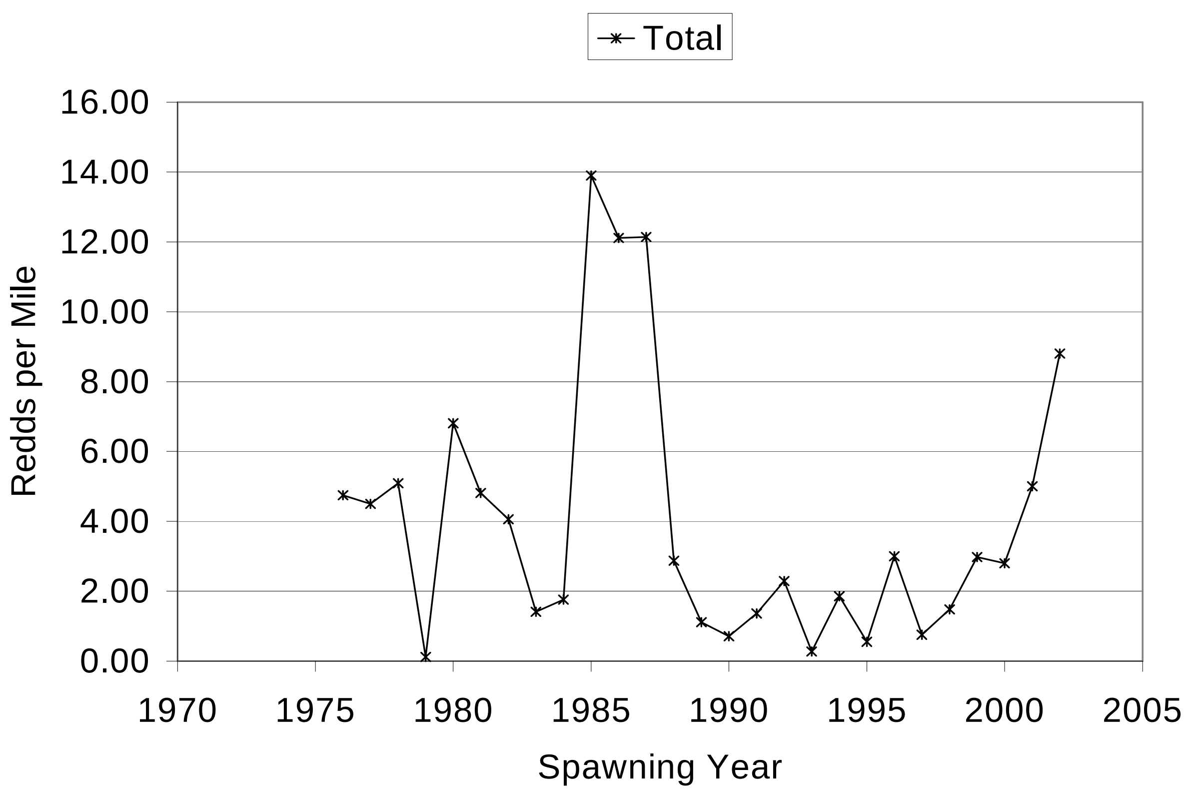


Figure B.2.3.10. Lower North Fork John Day steelhead redds per mile from index areas (Chilcote 2001).

B.2.4 LOWER COLUMBIA RIVER STEELHEAD

B.2.4.1 Summary of Previous BRT Conclusions

The status of Lower Columbia River steelhead was initially reviewed by NMFS in 1996 (Busby et al. 1996), and the most recent review occurred in 1998 (NMFS 1998a). In the 1998 review, the BRT noted several concerns for this ESU, including the low abundance relative to historical levels, the universal and often drastic declines observed since the mid-1980s, and the widespread occurrence of hatchery fish in naturally spawning steelhead populations. Analysis also suggested that introduced summer steelhead may negatively affect winter native winter steelhead in some populations. A majority of the 1998 BRT concluded that steelhead in the lower Columbia ESU were at risk of becoming endangered in the foreseeable future.

Current Listing Status: threatened

B.2.4.2 New Data and Update Analyses

New data available for this update included: recent spawner data, additional data on the fraction of hatchery-origin spawners, recent harvest rates, updated hatchery release information, and a compilation of data on resident *O. mykiss*. For many of the Washington chinook salmon populations, the Washington Department of Fish and Wildlife (WDFW) has conducted analyses using the Ecosystem Diagnosis and Treatment (EDT) model (Busack and Rawding 2003). The EDT model attempts to predict fish population performance based on input information about reach-specific habitat attributes (http://www.olympus.net/community/dungenesswc/EDT-primer.pdf). New analyses for this update include the designation of demographically independent populations, recalculation of previous BRT metrics with additional years' data, estimates of median annual growth rate (λ) under different assumptions about the reproductive success of hatchery fish, and estimates of current and historically available kilometers of stream.

Results of new analyses

Historical population structure—As part of its effort to develop viability criteria for Lower Columbia River steelhead, The Willamette/Lower Columbia Technical Recovery Team (WLC-TRT) has identified historically demographically independent populations (Myers et al. 2002). Population boundaries are based on an application of Viable Salmonid Populations definition (McElhany et al. 2000). Myers et al. hypothesized that the ESU historically consisted of 17 winter-run populations and six summer-run populations for a total of 23 populations (Figures B.2.4.1 and B.2.4.2). The populations identified in Myers et al. are used as the units for the new analyses in this report.

The WLC-TRT partitioned Lower Columbia River steelhead populations into a number of "strata" based on major life-history characteristics and ecological zones (McElhany et al. 2003). Analysis by the WLC-TRT suggests that a viable ESU would need multiple viable populations in each of these strata. The strata and associated populations are identified in Table B.2.4.1.

Table B.2.4.1. Historical population structure and abundance statistics for Lower Columbia River steelhead populations. The populations are partitioned into ecological zones and major life-history types. The ecological zones are based on ecological community and hydro dynamic patterns and life-history types are based on traits related to run timing. Time series used for the summary statistics are referenced in Appendix B.5.4.

<table>
<tr><th>Life History</th><th>Ecological Zone</th><th>Population</th><th>Years of Data for Recent Means</th><th>Recent Geometric Mean Total Spawners</th><th>Recent Arithmetic Mean Total Spawners</th><th>Recent Arithmetic Mean Percent Hatchery-origin Spawners</th></tr>
<tr><td rowspan="17">Winter Run</td><td rowspan="14">Cascade</td><td>Cispus River Winter Run</td><td rowspan="3">2002</td><td rowspan="3">2,787</td><td rowspan="3">2,787</td><td rowspan="3">73%</td></tr>
<tr><td>Tilton River Winter Run</td></tr>
<tr><td>Upper Cowlitz River Winter Run</td></tr>
<tr><td>Lower Cowlitz River Winter Run</td><td colspan="4">No Data</td></tr>
<tr><td>Coweeman River Winter Run</td><td>1998-2002</td><td>466</td><td>490</td><td>50%</td></tr>
<tr><td>South Fork Toutle River Winter</td><td>1998-2002</td><td>504</td><td>5034</td><td>2%</td></tr>
<tr><td>North Fork Toutle River Winter</td><td>1998-2002</td><td>196</td><td>207</td><td>0%</td></tr>
<tr><td>Kalama River Winter Run</td><td>1998-2002</td><td>726</td><td>797</td><td>0%</td></tr>
<tr><td>North Fork Lewis Winter Run</td><td colspan="4">No Data</td></tr>
<tr><td>East Fork Lewis Winter Run</td><td colspan="4">Index Data only; no abundance means available</td></tr>
<tr><td>Salmon Creek Winter Run</td><td colspan="4">No Data</td></tr>
<tr><td>Washougal River Winter Run</td><td>1998-2002</td><td>323</td><td>376</td><td>0%</td></tr>
<tr><td>Clackamas River Winter Run</td><td>1997-2001</td><td>560</td><td>717</td><td>41%</td></tr>
<tr><td>Sandy River Winter Run</td><td>1997-2001</td><td>977</td><td>997</td><td>42%</td></tr>
<tr><td rowspan="3">Gorge</td><td>Lower Gorge Tributaries Winter</td><td colspan="4">No Data</td></tr>
<tr><td>Upper Gorge Tributaries Winter</td><td colspan="4">No Data</td></tr>
<tr><td>Hood River Winter Run</td><td>1996-2000</td><td>756</td><td>792</td><td>52%</td></tr>
<tr><td>Summer Run</td><td>Cascade</td><td>Kalama River Summer Run</td><td>1999-2003</td><td>474</td><td>633</td><td>32%</td></tr>
</table>

		North Fork Lewis Summer Run	No Data			
		East Fork Lewis Summer Run	1999-2003	434	514	25%
		Washougal River Summer Run	1999-2003	264	313	8%
	Gorge	Wind River Summer Run	1999-2003	472	535	5%
		Hood River Summer Run	1996-2000	931	1,003	83%

Abundance and trends

References for abundance time series and related data are in Appendix B.5.4. Recent abundance of total spawners, and recent fraction of hatchery-origin spawners for Lower Columbia River steelhead populations are summarized in Table B.2.4.1. The abundance means in Table B.2.4.1 are for total spawners and include both natural and hatchery-origin fish. Natural-origin fish had parents that spawned in the wild as opposed to hatchery-origin fish whose parents were spawned in a hatchery. A number of the populations have a substantial fraction of hatchery-origin spawners in the spawning areas and are hypothesized to be sustained largely by hatchery production. Exceptions are the Kalama, the North Fork Toutle, the South Fork Toutle, and East Fork Lewis winter-run populations, which have few hatchery fish spawning on the natural spawning areas. These populations have relatively low recent mean abundance estimates, with the largest being the Kalama (geometric mean of 726 spawners).

The pooled estimate of abundance for the historical Cispus, Tilton and Upper Cowlitz populations has the highest recent total spawner abundance in the ESU, but also the largest fraction of hatchery-origin spawners. The hatchery-origin spawners are part of a reintroduction program to establish steelhead above Cowlitz Falls dam, the upper most of impassable three dams on the mainstem Cowlitz (Serl and Morrill 2002). Adults are collected below the most downstream dam (Mayfield) and trucked above Cowlitz Falls. Downstream survival of juvenile steelhead though the dams and reservoirs is considered negligible, so juveniles are collected at Cowlitz Falls and trucked downstream. The current collection efficiency of juveniles at Cowlitz Falls is considered too low for the reintroduction to be self-sustaining (Rawding 2003 pers. com.).

Where data are available, the abundance time series information for each of the populations is presented in Figures B.2.4.3.-B.2.4.23. Two types of time series figures are presented. The first type of figure plots abundance over time (Figures B.2.4.3, B.2.4.5, B.2.4.7, B.2.4.9, B.2.4.11, B.2.4.13, B.2.4.15-B.2.4.19, B.2.4.21, and B.2.4.23). Where possible, two lines are presented on the abundance figure, where one line is the total number of spawners (or total count at a dam) and the other line is the number of fish of natural origin. In some cases, data were not available to distinguish between natural and hatchery-origin spawners, so only total spawner (or dam count) information is presented. This type of figure can give a sense of the levels of abundance, overall trend, patterns of variability, and the fraction of hatchery-origin spawners.

The second type of time-series figure presents the total number of spawners (natural and hatchery origin) and the number of preharvest recruits produced by those spawners over broodyear (Figures B.2.4.4, B.2.4. 6, B.2.4.8, B.2.4.10, B.2.4.12, B.2.4.14, B.2.4.20, B.2.4.22, B.2.4.24). Dividing the number of preharvest recruits by the number of spawners for the same time period would yield an estimate of the preharvest recruits per spawner. This type of figure requires harvest and age structure information, and therefore, could be produced for only a limited number of populations. This type of figure can indicate if there have been changes in preharvest recruitment and the degree to which harvest management has the potential to recover populations. If the preharvest recruitment line is consistently below the spawner line, it indicates that the population would not be replacing itself, even in the absence of all harvest.

Summary statistics on population trends and growth rate are presented in Tables B.2.4.2-B.2.4.5 and in Figures B.2.4.25- B.2.4.27. The methods for estimating trends and growth rate (λ) are described in the general methods section. The majority of populations have a long-term trend less than one, indicating the population is in decline. In addition, there is a high probability for most populations that the true trend/growth rate is less than one (Table B.2.4.3). When growth rate is estimated, assuming that hatchery-origin spawners have a reproductive success equal to that of natural-origin spawners, all of the populations have a negative growth rate except the North Fork Toutle winter run, which had very few hatchery-origin spawners (Figure B.2.4.23). The North Fork Toutle population is recovering from the eruption of Mt. St. Helens in 1980 and is still at low abundance (recent mean of 196 spawners). The potential reasons for these declines have been cataloged in previous status reviews and include habitat degradation, deleterious hatchery practices, and climate-driven changes in marine survival.

Rawding (2003) suggests that marine conditions have been a major factor driving the decline observed in the available time series and that marine survival is largely responsible for the increases observed in the last few years. He poses as an important question: What will happen to Lower Columbia River steelhead when the ocean cycles to less productive regimes again? This general issue is discussed in the introduction to the update reports, as it applies to many ESUs.

Table B.2.4.2. Long-term trend and growth rate for a subset of Lower Columbia steelhead populations for which adequate data are available (95% C.I. are in parentheses). The long-term analysis used the entire data set. The trend estimate is for total spawners and includes both natural-origin and hatchery-origin fish. The λ calculation is an estimate of what the natural growth rate would have been after accounting for hatchery-origin spawners. The λ estimate is calculated under two hypotheses about the reproductive success of hatchery-origin spawners. In "Hatchery = 0" columns, hatchery fish are assumed to have zero reproductive success. In the "Hatchery = Wild" columns, hatchery fish are assumed to have the same relative reproductive success as natural-origin fish.

Run	**Population**	**Years for Trend and λ**	**Trend of Total Spawners**	**Median Growth Rate (λ)**	
				Hatchery = 0	**Hatchery = Wild**

Winter	Coweeman	1987-2002	0.916 (0.847-0.990)	0.908 (0.792-1.041)	0.782 (0.678-0.903)
	South Fork Toutle	1984-2002	0.917 (0.876-0.961)	0.938 (0.830-1.059)	0.933 (0.821-1.061)
	North Fork Toutle	1989-2002	1.135 (1.038-1.242)	1.062 (0.915-1.233)	1.062 (0.915-1.233)
	Kalama	1977-2002	0.998 (0.973-1.023)	1.010 (0.913-1.117)	0.916 (0.824-1.019)
	Clackamas	1958-2001	0.979 (0.966-0.993)	0.971 (0.901-1.047)	0.949 (0.877-1.027)
	Sandy	1978-2001	0.940 (0.919-0.960)	0.945 (0.850-1.051)	0.828 (0.741-0.925)
Summer	Kalama	1977-2003	0.928 (0.889-0.969)	0.981 (0.889-1.083)	0.712 (0.642-0.790)
	Washougal	1986-2003	0.991 (0.942-1.043)	1.003 (0.884-1.138)	0.996 (0.872-1.138)
	Wind	1989-2003	0.973 (0.921-1.028)	0.983 (0.853-1.134)	0.937 (0.807-1.089)

Table B.2.4.3. Short-term trend and growth rate for a subset of Lower Columbia steelhead populations for which adequate data are available (95% C.I. are in parentheses). Short-term data sets include data from 1990 to the most recent available year. The trend estimate is for total spawners and includes both natural-origin and hatchery-origin fish. The λ calculation is an estimate of what the natural growth rate would have been after accounting for hatchery-origin spawners. The λ estimate is calculated under two hypotheses about the reproductive success of hatchery-origin spawners. In "Hatchery = 0" columns, hatchery fish are assumed to have zero reproductive success. In the "Hatchery = Wild" columns, hatchery fish are assumed to have the same relative reproductive success as natural-origin fish.

Run	**Population**	**Years for Trend**	**Trend of Total Spawners**	**Median Growth Rate (λ)**	
				Hatchery = 0	**Hatchery = Wild**
Winter	Coweeman	1990-2002	0.941 (0.818-1.083)	0.920 (0.803-1.055)	0.787 (0.682-0.909)
	South Fork Toutle	1990-2002	0.939 (0.856-1.130)	0.933 (0.826-1.054)	0.929 (0.817-1.056)
	North Fork Toutle	1990-2002	1.086 (0.999-1.018)	1.038 (0.894-1.206)	1.038 (0.894-1.206)
	Kalama	1990-2002	1.004 (0.923-1.091)	0.984 (0.890-1.088)	0.922 (0.829-1.025)
	Clackamas	1990-2001	0.914 (0.806-1.036)	0.875 (0.812-0.943)	0.830 (0.767-0.898)
	Sandy	1990-2001	0.889 (0.835-0.946)	0.866 (0.797-0.985)	0.782 (0.700-0.874)
Summer	Kalama	1990-2003	0.855 (0.756-0.968)	0.900 (0.816-0.994)	0.664 (0.598-0.737)
	Washougal	1990-2003	1.024 (0.951-1.104)	1.029 (0.907-1.168)	0.960 (0.841-1.097)

	Wind	1990-2003	0.989 (0.931-1.049)	0.995 (0.863-1.148)	0.903 (0.777-1.049)

Table B.2.4.4. Probability that the long-term abundance trend or growth rate of a subset of Lower Columbia River steelhead populations is less than one. In the "Hatchery = 0" columns, the hatchery-origin fish are assumed to have zero reproductive success. In the "Hatchery = Wild" columns, hatchery-origin fish are assumed to have reproductive success equivalent to that of natural-origin fish.

Run	Population	Years for Trend and λ	Prob. Trend <1	Prob. λ < 1	
				Hatchery = 0	Hatchery = Wild
Winter	Coweeman	1987-2002	0.985	0.936	1.000
	South Fork Toutle	1984-2002	0.999	0.884	0.899
	North Fork Toutle	1989-2002	0.005	0.063	0.063
	Kalama	1977-2002	0.574	0.405	0.971
	Clackamas	1958-2001	0.998	0.784	0.918
	Sandy	1978-2001	1.000	0.993	1.000
Summer	Kalama	1977-2003	0.999	0.613	1.000
	Washougal	1986-2003	0.644	0.476	0.526
	Wind	1989-2003	0.848	0.639	0.889

Table B.2.4.5. Probability that the long-term abundance trend or growth rate of a subset of Lower Columbia River steelhead populations is less than one. In the "Hatchery = 0" columns, the hatchery-origin fish are assumed to have zero reproductive success. In the "Hatchery = Wild" columns, hatchery-origin fish are assumed to have reproductive success equivalent to that of natural-origin fish.

Run	Population	Years for Trend	Prob. Trend <1	Prob. λ < 1	
				Hatchery = 0	Hatchery = Wild
Winter	Coweeman	1990-2002	0.822	0.851	0.995
	South Fork Toutle	1990-2002	0.919	0.797	0.812
	North Fork Toutle	1990-2002	0.026	0.135	0.135
	Kalama	1990-2002	0.463	0.593	0.846
	Clackamas	1990-2001	0.929	0.849	0.929
	Sandy	1990-2001	0.999	0.991	1.000
Summer	Kalama	1990-2003	0.991	0.849	1.000
	Washougal	1990-2003	0.249	0.349	0.757
	Wind	1990-2003	0.659	0.538	0.989

EDT-based estimates of historical abundance—The Washington Department of Fish and Wildlife (WDFW) has conducted analyses of the Lower Columbia River chinook populations using the Ecosystem Diagnosis and Treatment (EDT) model (Busack and Rawding 2003). WDFW populated this model with estimates of historical habitat condition, which produced the estimates of average historical abundance shown in Table B.2.4.6. There is a great deal of unquantified uncertainty in the EDT historical abundance estimates, which should be taken into consideration when interpreting these data. In addition, the habitat scenarios evaluated as "historical" may not reflect historical distributions, since some areas that were historically accessible but currently blocked by large dams are omitted from the analyses and some areas that were historically inaccessible but recently passable because of human intervention are included. The EDT outputs are provided here to give a sense of the historical abundance of populations relative to each other and an estimate of the historical abundance relative to the current abundance.

Table B.2.4.6. EDT based estimates of historical abundance for a subset of Lower Columbia River steelhead populations.

Life History	Population	EDT Estimate of Historical Abundance
Winter Run	Coweeman River Winter Run	2,243
	Lower Cowlitz River Winter Run	1,672
	South Fork Toutle River Winter	2,627
	North Fork Toutle River Winter	3,770
	Kalama River Winter Run	554
	North Fork Lewis Winter Run	713
	East Fork Lewis Winter Run	3,131
	Salmon Creek Winter Run	
	Washougal River Winter Run	2,497
	Lower Gorge Tributaries Winter	793
	Upper Gorge Tributaries Winter	243
	Hood River Winter Run	
Summer Run	Kalama River Summer Run	3,165
	East Fork Lewis Summer Run	422
	Washougal River Summer Run	1,419
	Wind River Summer Run	2,288

Loss of habitat from barriers—An analysis was conducted by Steel and Sheer (2003) to assess the number of stream km historically and currently available to salmon populations in the Lower Columbia River (Table B.2.4.7). Stream km usable by salmon are determined based on simple gradient cut offs and on the presence of impassable barriers. Barriers with passage limited to trap-and-haul are considered impassible for this analysis. This approach will over estimate the number of usable stream km as it does not take into consideration habitat quality (other than gradient). However, the analysis does indicate that for some populations, the number of stream habitat km currently accessible is greatly reduced from the historical condition.

Table B.2.4.7. Loss of habitat from barriers. The potential current habitat is the kilometers of stream below all currently impassible barriers between a gradient of 0.5% and 4%. The potential historical habitat is the kilometers of stream below historically impassible barriers between a gradient of 0.5% and 4% (summer) and 0.5% and 6% (winter). The current to historical habitat ratio is the percent of the historical habitat that is currently available.

Population	Potential Current Habitat	Potential Historical Habitat (km)	Current to Historical Habitat Ratio
Cispus River Winter Run	0	87	0%
Coweeman River Winter Run	85	102	84%
Lower Cowlitz River Winter Run	542	674	80%
Upper Cowlitz River Winter Run	6	358	2%
Tilton River Winter Run	0	120	0%
South Fork Toutle River Winter	82	92	8%
North Fork Toutle River Winter	209	330	63%
Kalama River Winter Run	112	122	92%
North Fork Lewis Winter Run	115	525	22%
East Fork Lewis Winter Run	239	315	76%
Salmon Creek Winter Run	222	252	88%
Washougal River Winter Run	122	232	53%
Clackamas River Winter Run	919	1,127	82%
Sandy River Winter Run	295	386	76%
Lower Gorge Tributaries Winter	46	46	99%
Upper Gorge Tributaries Winter	31	31	100%
Hood River Winter Run	138	138	99%
Kalama River Summer Run	49	54	90%
North Fork Lewis Summer Run	78	83	94%
East Fork Lewis Summer Run	87	364	24%
Washougal River Summer Run	181	236	77%
Wind River Summer Run	84	164	51%
Hood River Summer Run	36	41	90%
Total	3,678	5,879	63%

Resident *O. mykiss* considerations

The available information on resident *O. mykiss* populations within the ESU is summarized in Table B.2.1.3 and Appendix B.5.1 and provides a broad overview of the distribution of Case 1, 2, and 3 resident populations within the ESU. See the section on Resident Fish in the Introduction section to the main body of this report for an explanation of the three cases and their relevance to ESU determinations. The section on Resident Fish in section B.1 of this steelhead report discusses how resident fish are considered in risk analyses.

Kostow (2003) has reviewed information on the abundance and distribution of resident *O. mykiss* for this ESU and found no quantitative estimates of abundance for resident *O. mykiss* in any LCR population. However, expert opinion on the distribution and relative abundance of resident *O. mykiss* is available. Expert opinion suggests that resident *O. mykiss* numerically dominate the Wind River Basin, and the West Fork of the Hood basin. However they are considered less common in other portions of the Hood basin. Residents are considered common in the Collowash subbasin of the Clackamas, though rare or possibly absent in other parts of the basin below natural barriers. Resident *O. mykiss* are considered abundant above the Bull Run dams (1929) in the Sandy basin, Merwin Dam (1931) in the Lewis basin and Mayfield Dam (1963) in the Cowlitz basin, but are rare or absent elsewhere in these basins. We are not aware of specific information relevant to the ESU status of Case 3 resident populations above the dams in the Cowlitz, Lewis, or Sandy Rivers. Resident *O. mykiss* are probably common in the upper portions of the Kalama and Washougal basins, but rare in the lower portions. Resident *O. mykiss* are considered absent from all the smaller lower Columbia tributaries that have small patches of spawning anadromous *O. mykiss*. Cutthroat trout, *Oncorhynchus clarki,* tend not to co-occur with resident *O. mykiss* and appear to have historically been the predominant resident trout species in many of the lower Columbia tributaries.

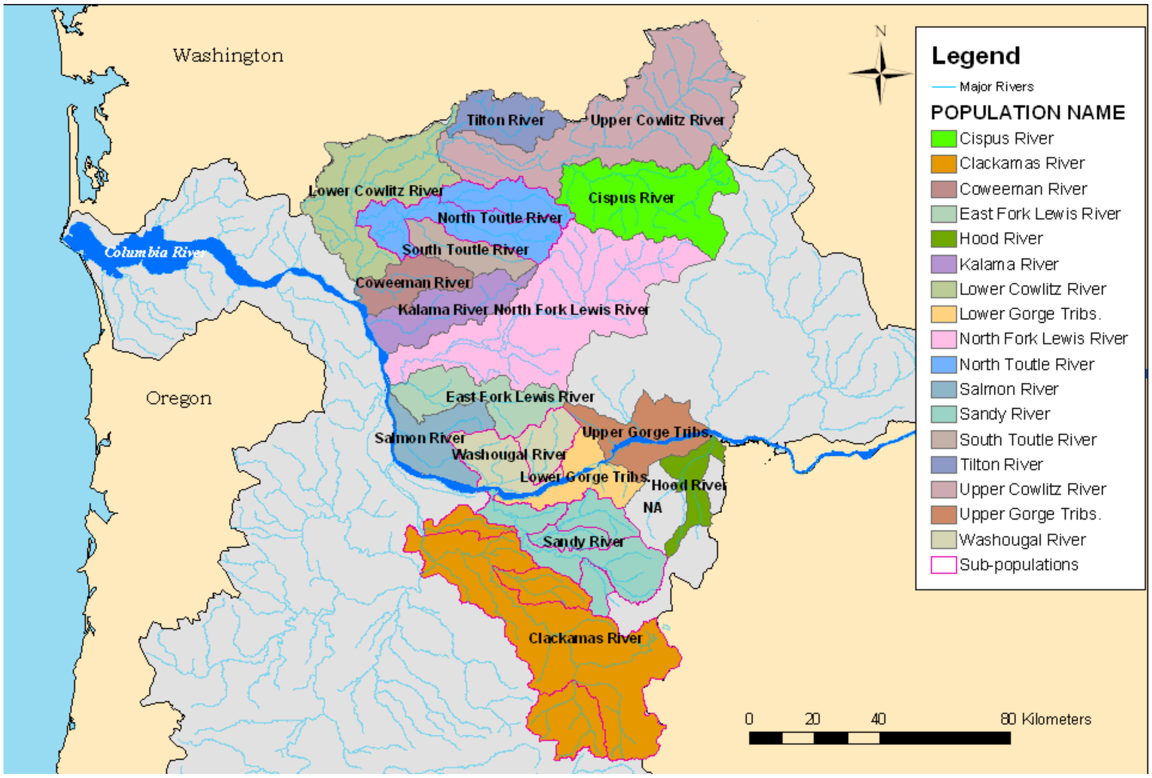


Figure B.2.4.1. Historical populations of winter steelhead in the Lower Columbia ESU (Myers et al. 2002).

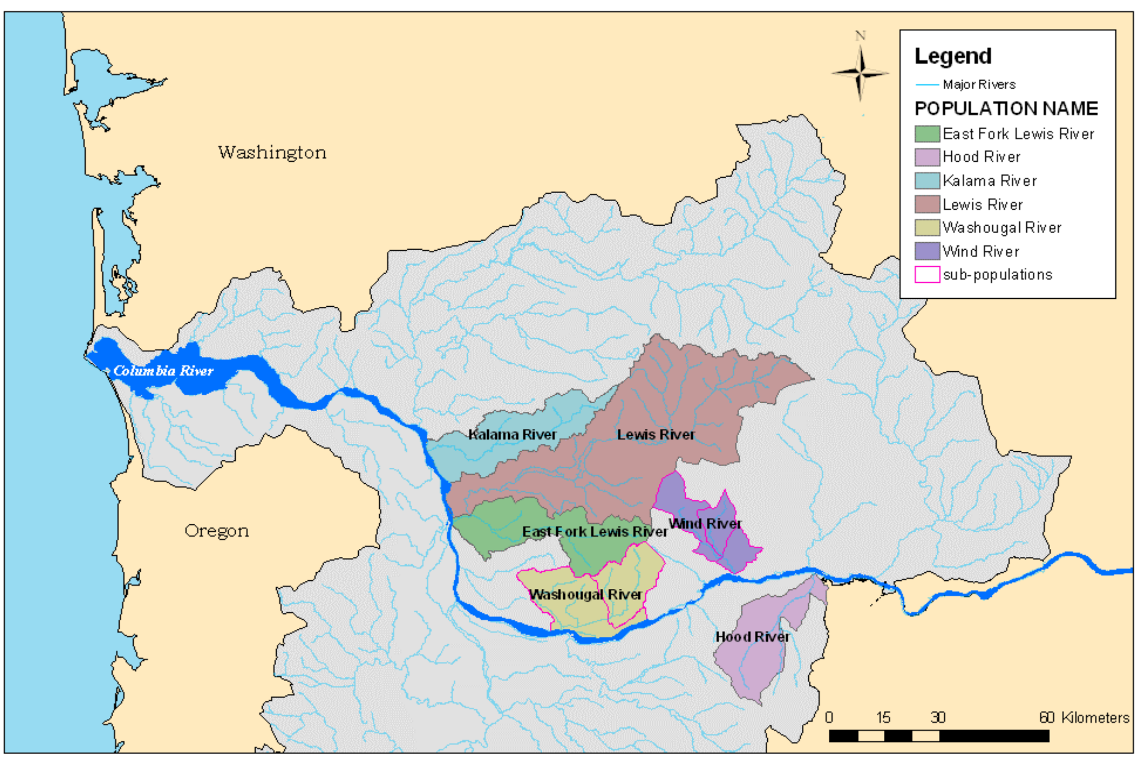


Figure B.2.4.2. Historical populations of summer steelhead in the Lower Columbia ESU (Myers et al. 2002).

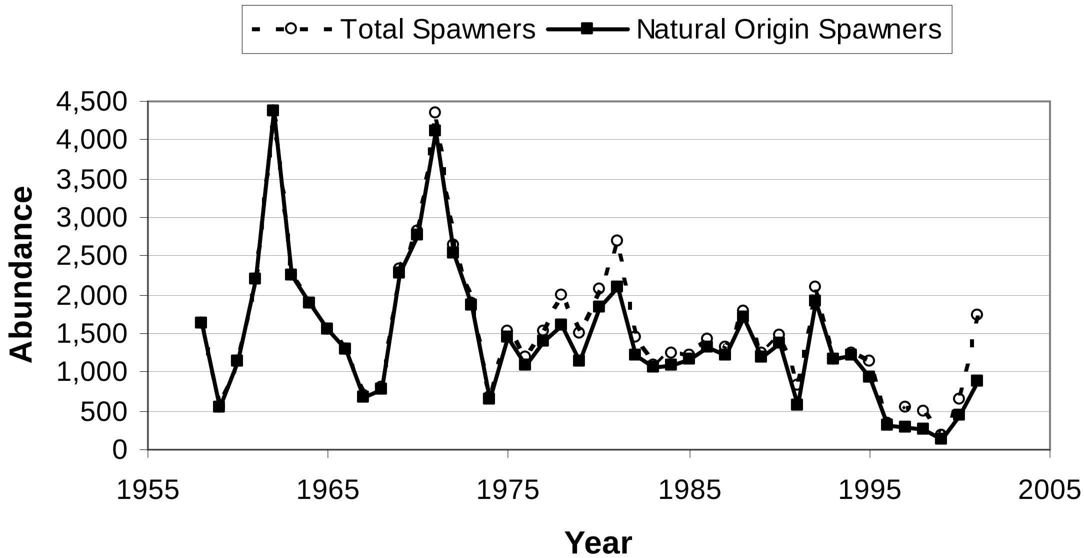


Figure B.2.4.3. Winter steelhead abundance at North Fork dam on Clackamas River (data from Cramer 2002).

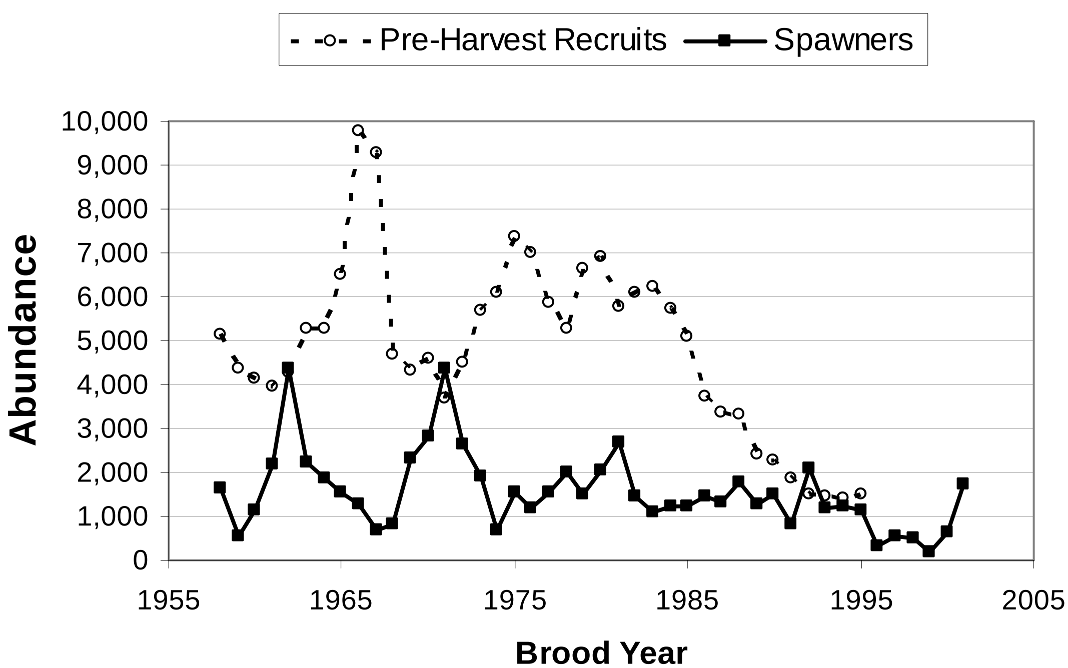
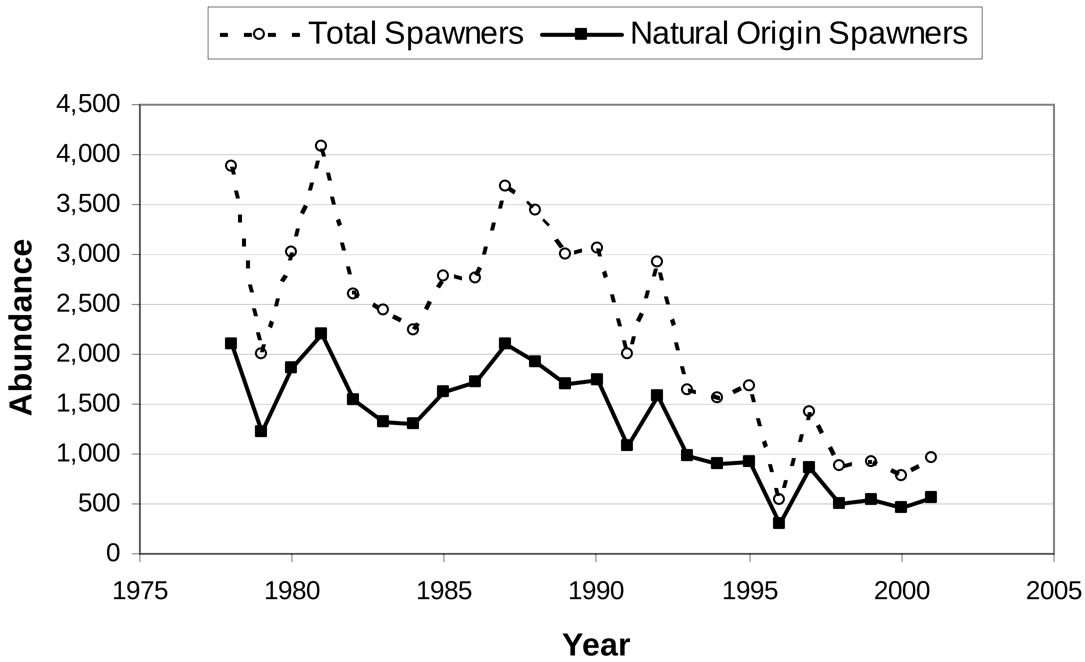
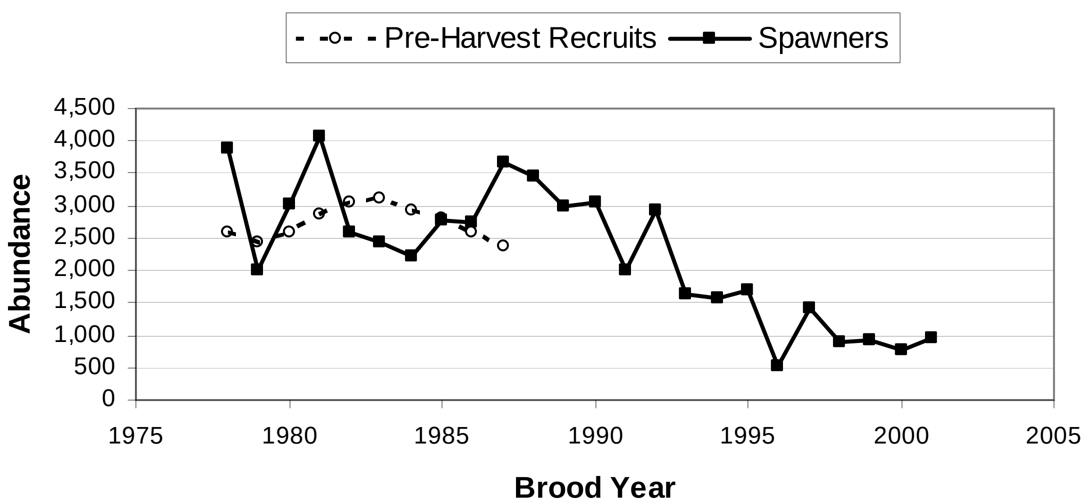


Figure B.2.4.4. Preharvest recruits and spawners for winter steelhead estimated from counts at North Fork Dam on the Clackamas River.



B.2.4.5. Winter steelhead abundance at Marmot dam on the Sandy River (data from Cramer 2002).



B.2.4.6. Preharvest recruits and spawners for winter steelhead estimated from counts at Marmot Dam on the Sandy River.

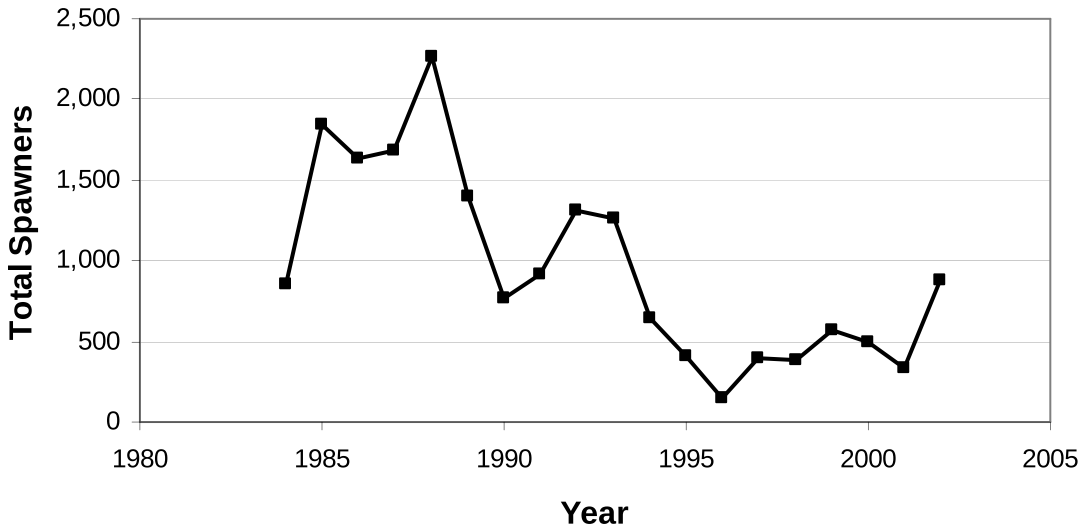


Figure B.2.4.7. Estimate of winter steelhead spawner abundance in the South Fork Toutle River. It is estimated that approximately 2% of the total spawners may be of natural origin.

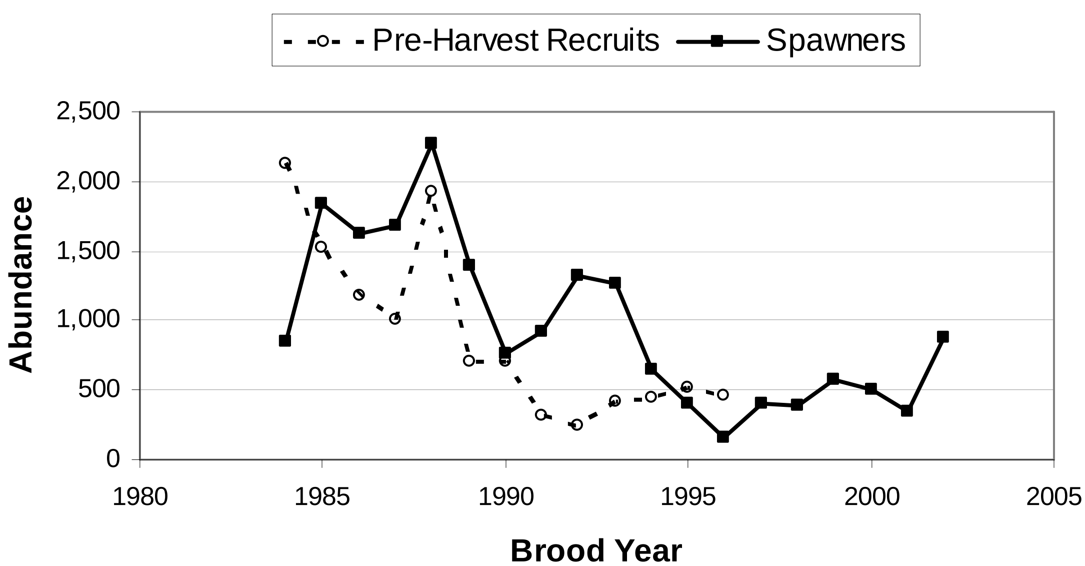


Figure B.2.4.8. Estimate of winter steelhead preharvest recruits and spawners in the South Fork Toutle River.

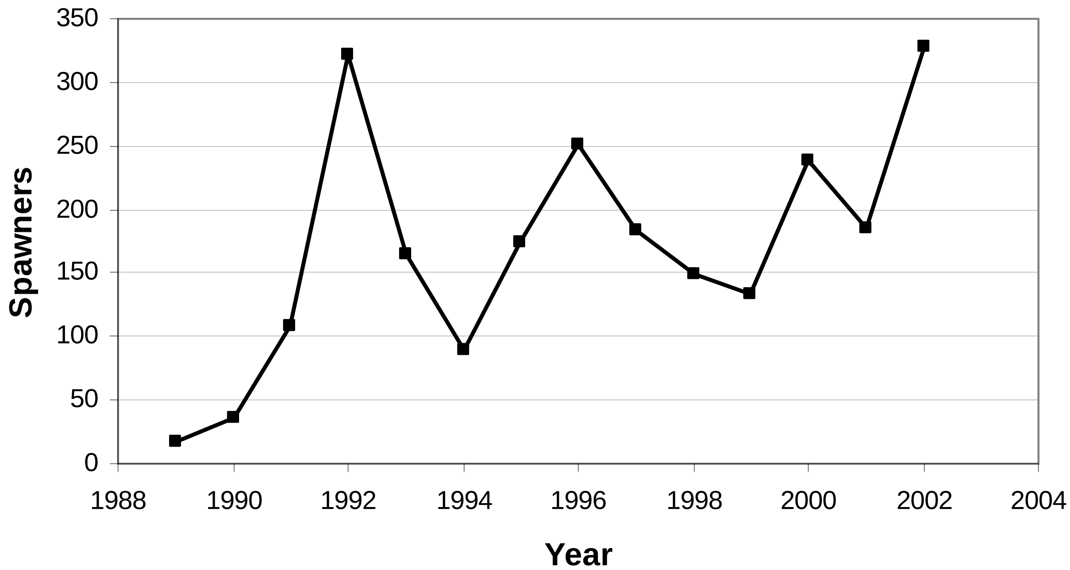


Figure B.2.4.9. Estimate of winter steelhead abundance in the North Fork Toutle. There are estimated to be no hatchery-origin spawners in the North Fork Toutle population.

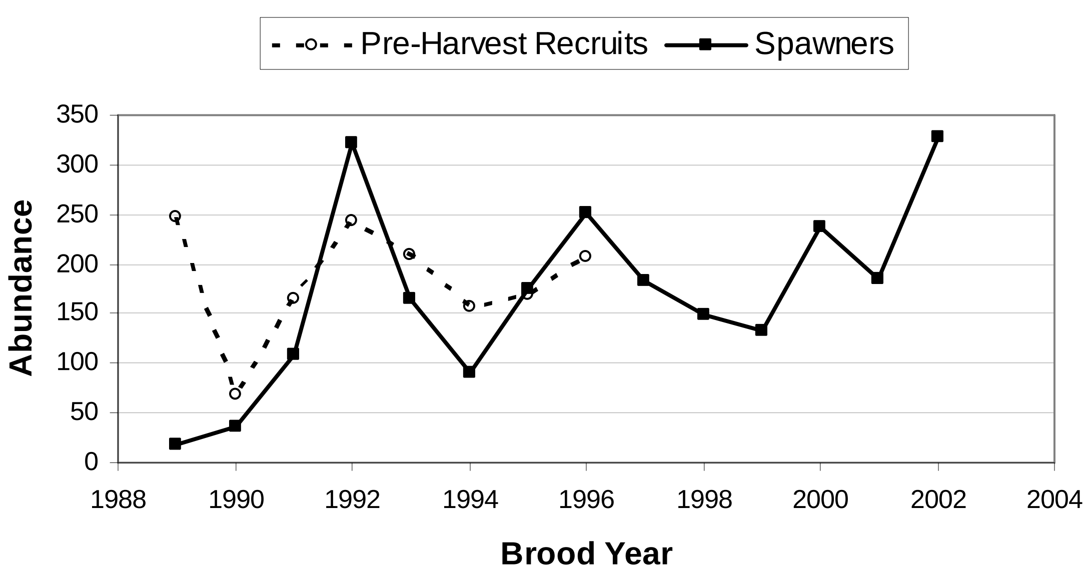
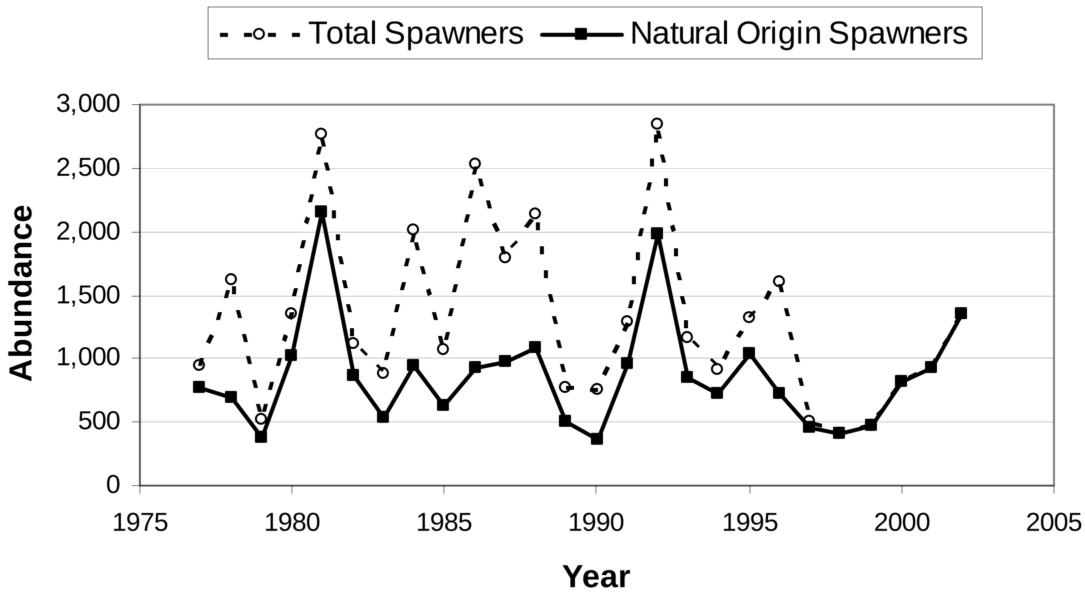


Figure B.2.4.10. Estimate of winter steelhead preharvest recruits and spawners in the North Fork Toutle River.



B.2.4.11. Estimate of winter steelhead abundance in the Kalama River.

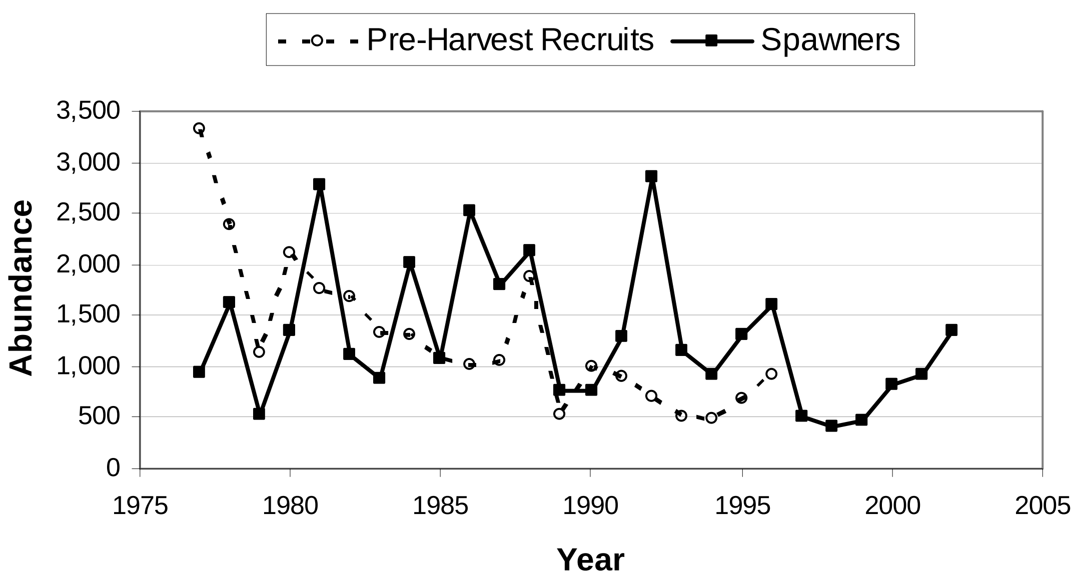
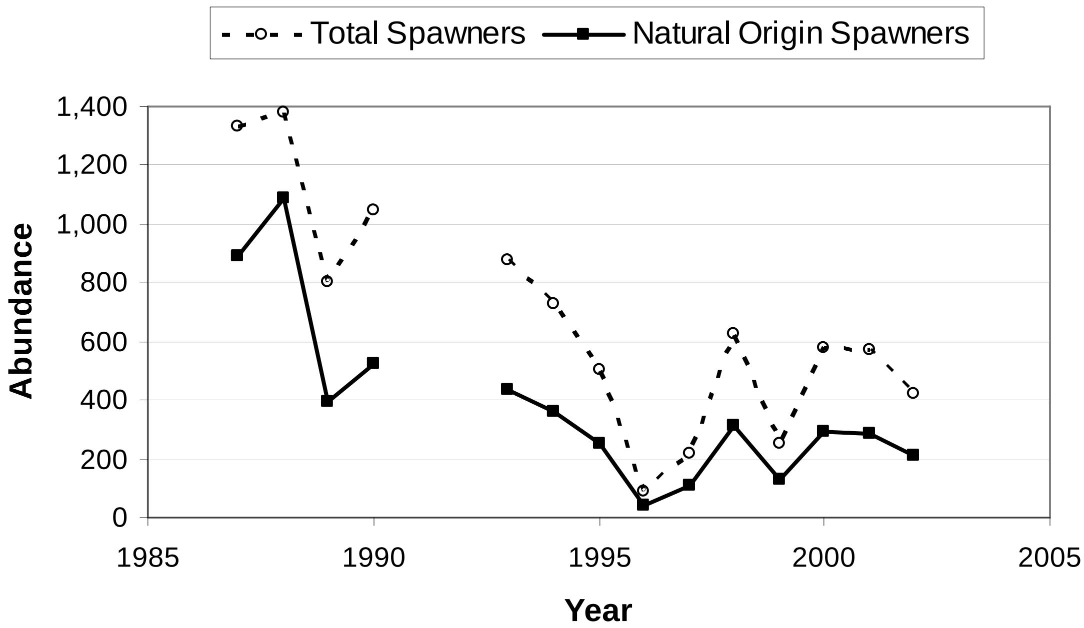


Figure B.2.4.12. Estimate of winter steelhead preharvest recruits and spawners in the Kalama River.



B.2.4.13. Estimate of winter steelhead abundance in the Coweeman River.

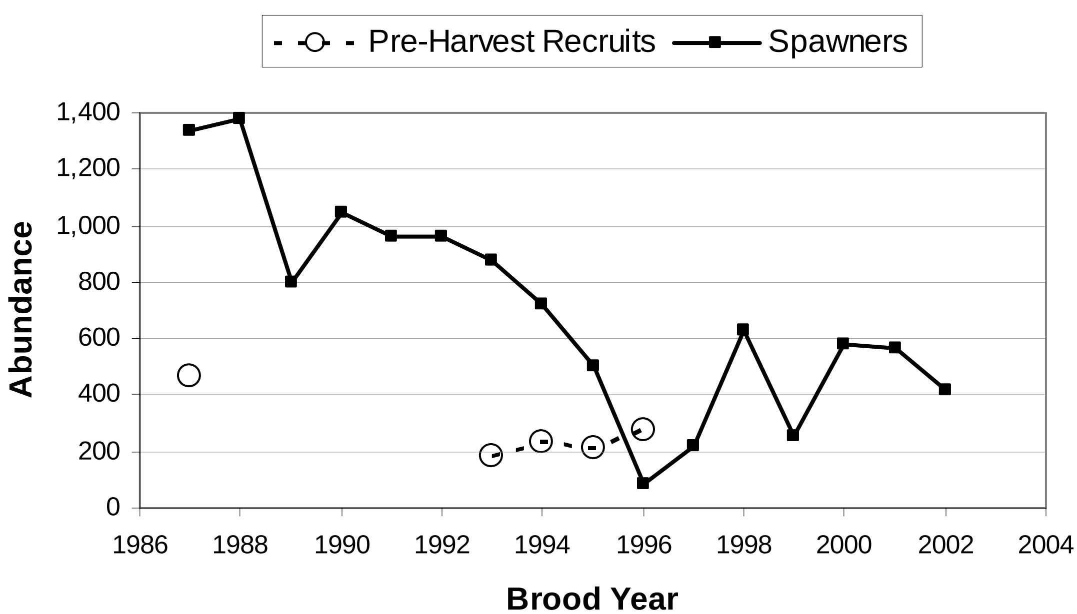


Figure B.2.4.14. Estimate of winter steelhead preharvest recruits and spawners in the Coweeman River.

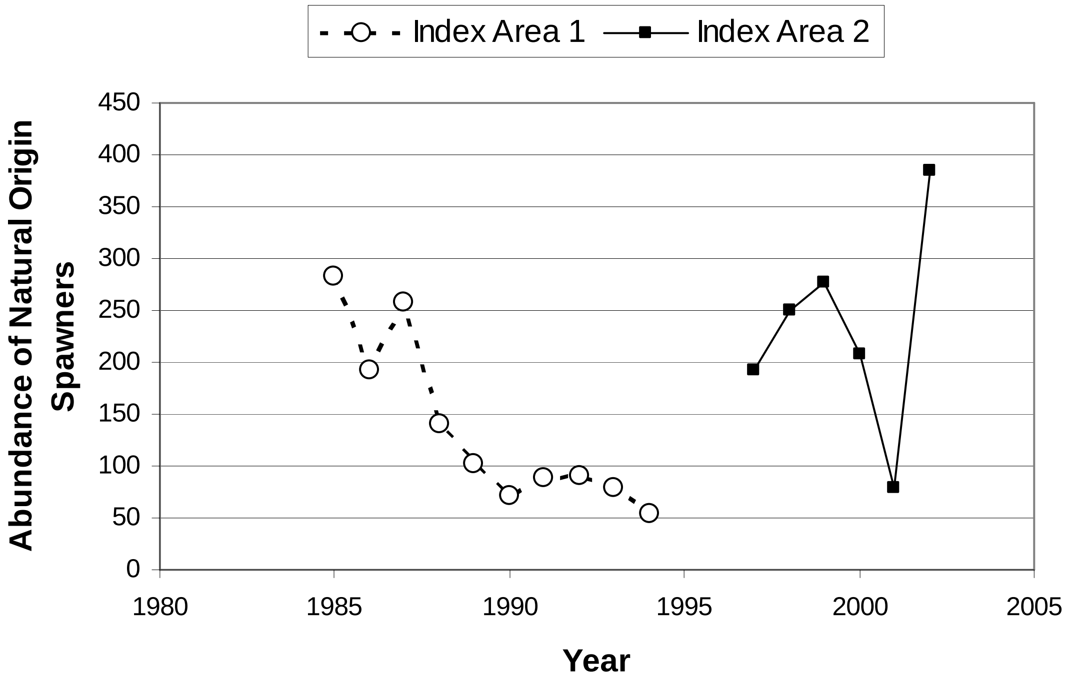


Figure B.2.4.15. Index counts of natural-origin winter steelhead in the East Fork of the Lewis River. The two indexes are for different areas and cannot be directly compared and cannot be used to create a more continuous time trend.

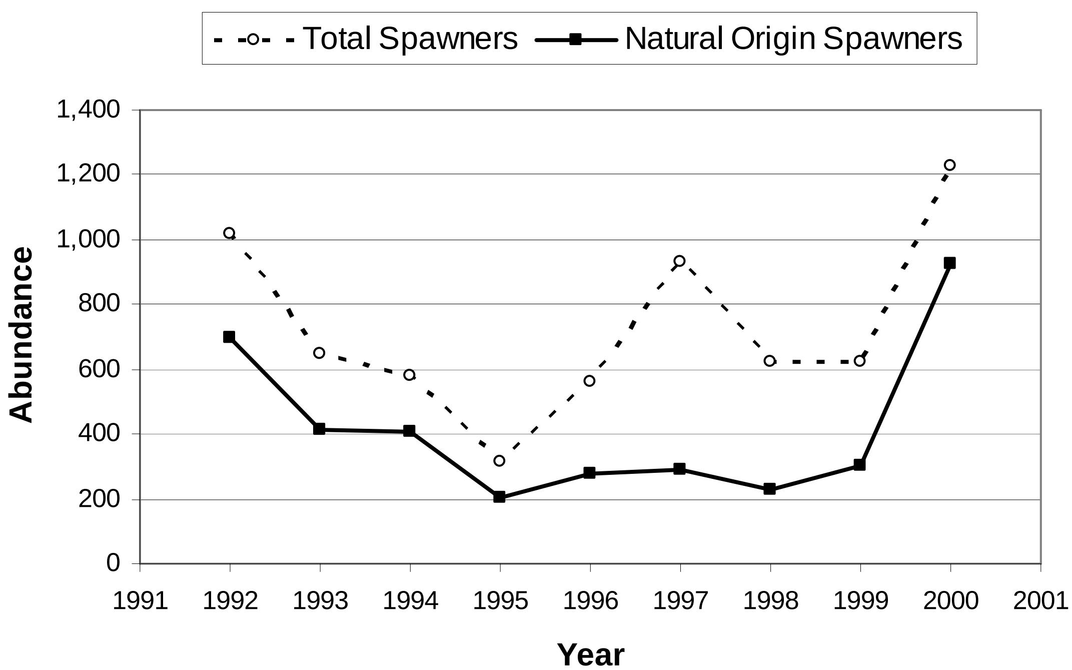


Figure B.2.4.16. Estimate of winter steelhead abundance in the Hood River.

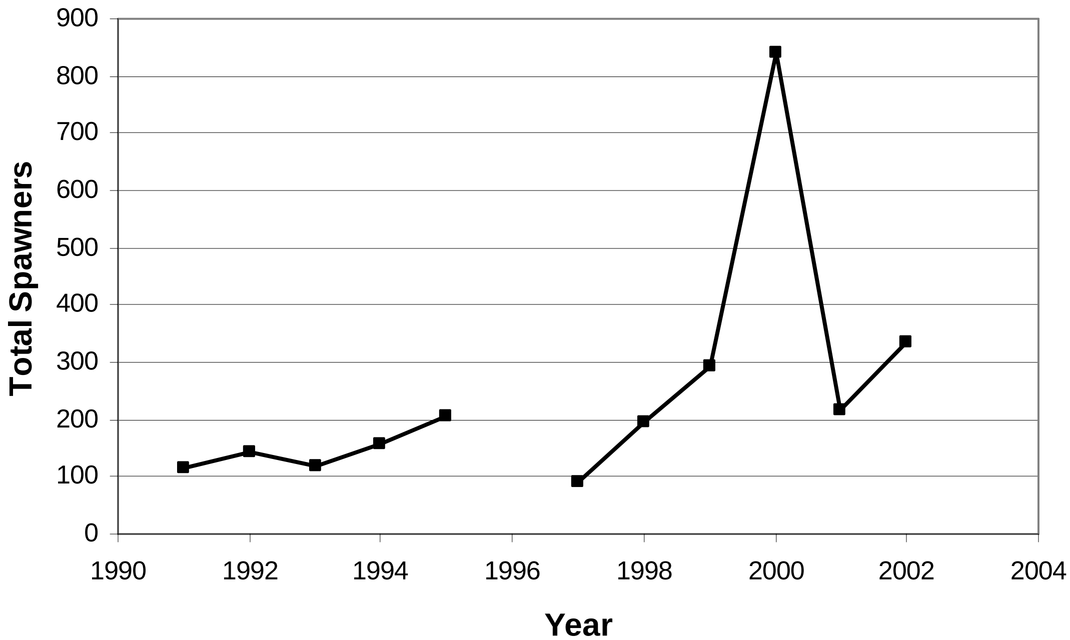
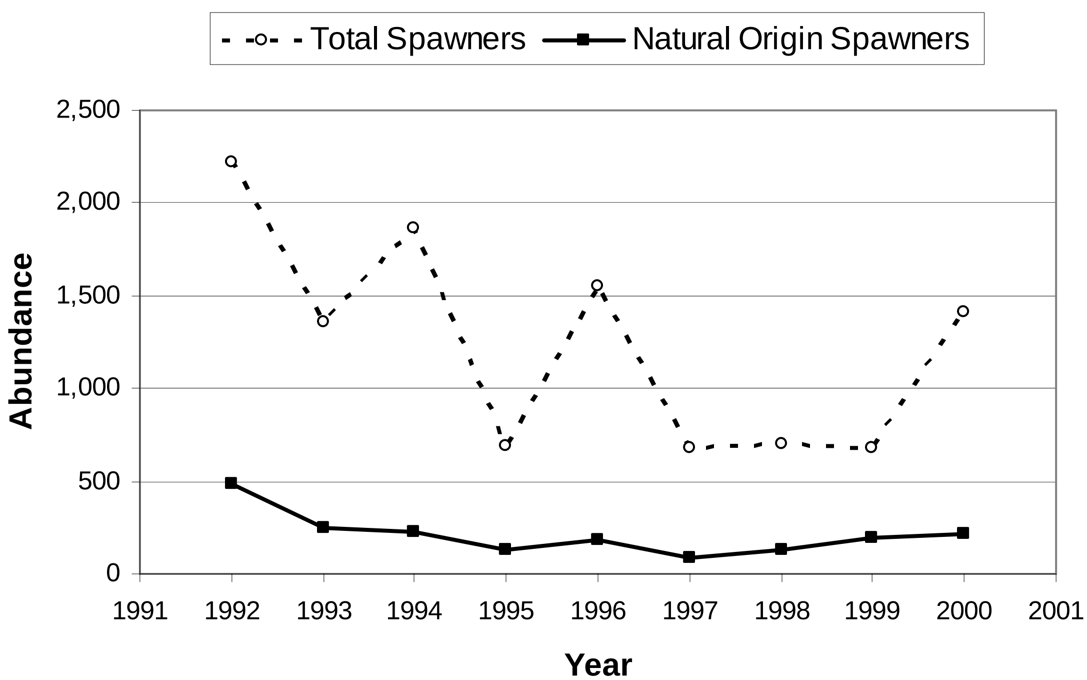
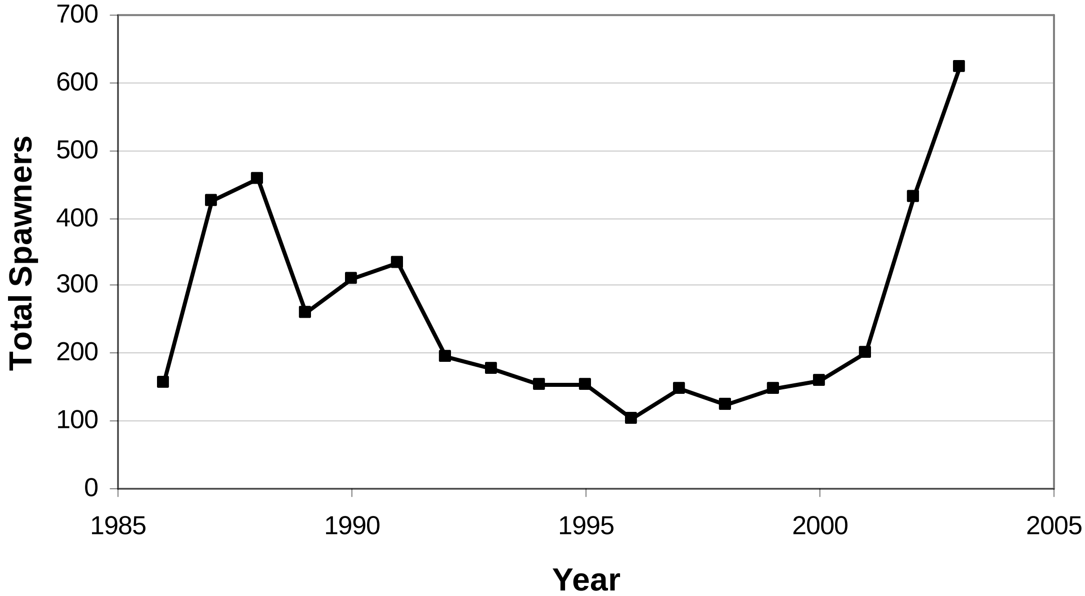


Figure B.2.4.17. Estimate of winter steelhead abundance in the Washougal River. The percent of hatchery-origin spawners is considered minimal.



B.2.4.18. Estimate of summer steelhead abundance in the Hood River.



B.2.4.19. Estimate of the total summer steelhead abundance in the Washougal River. The fraction of hatchery-origin fish is minimal (avg. approx. 3%)

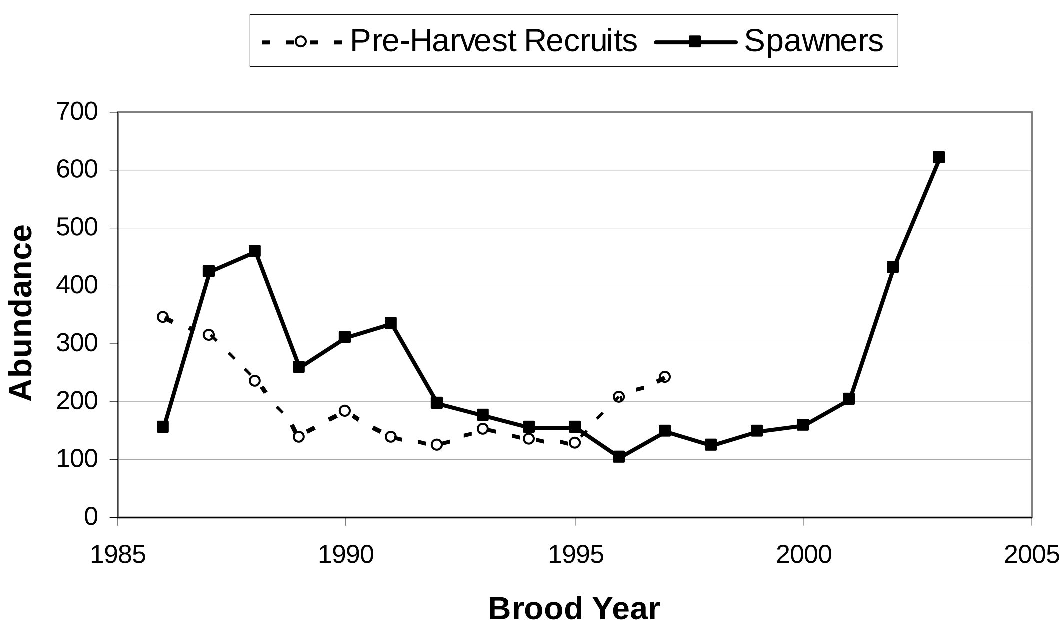
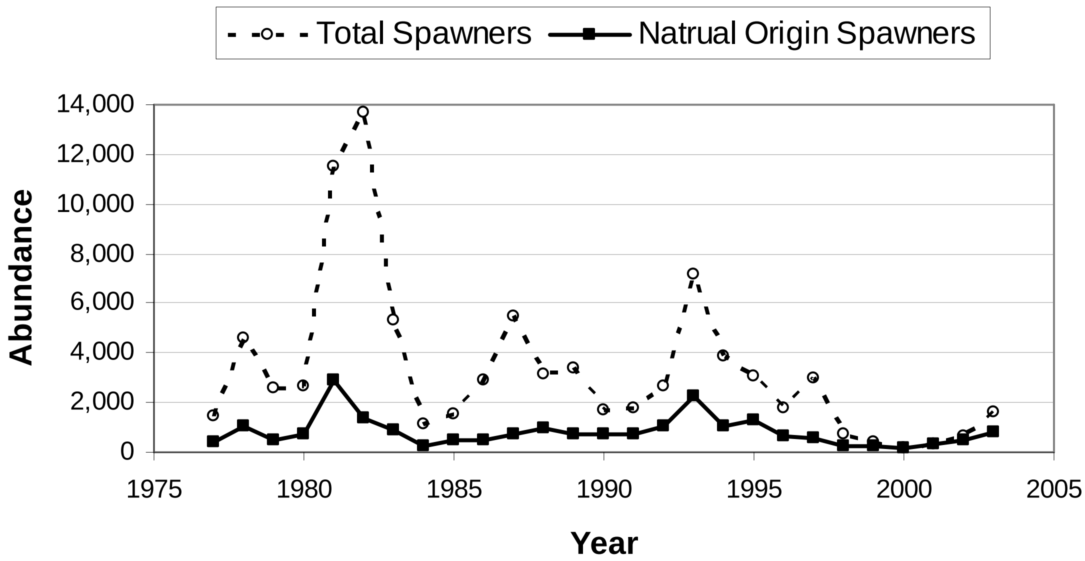


Figure B.2.4.20. Estimate of summer steelhead preharvest recruits and spawners in the Washougal River.



B.2.4.21. Estimate of summer steelhead abundance in the Kalama River.

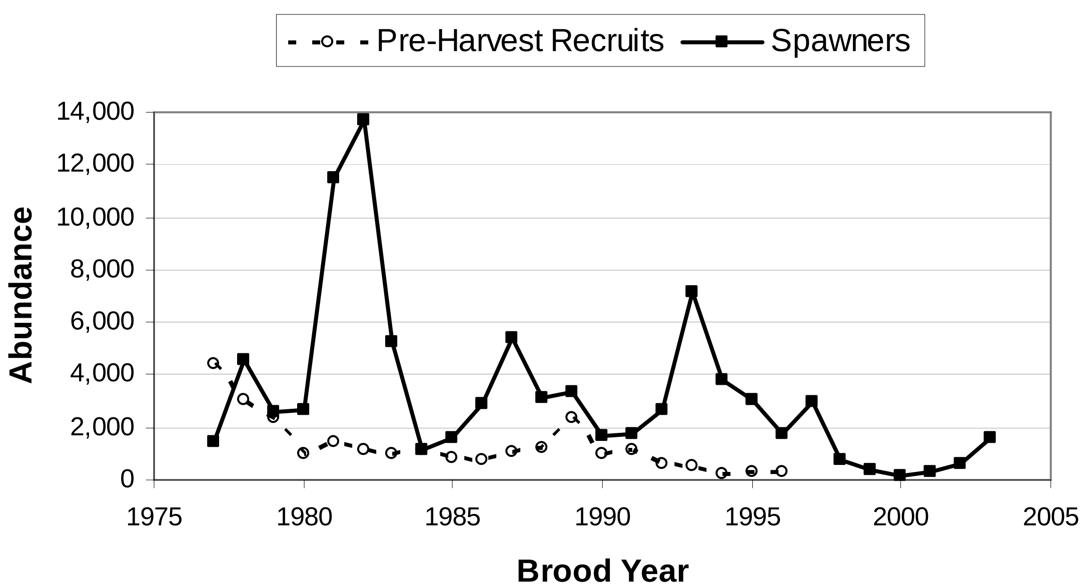


Figure B.2.4.22. Estimate of summer steelhead preharvest recruits and spawners in the Kalama River.

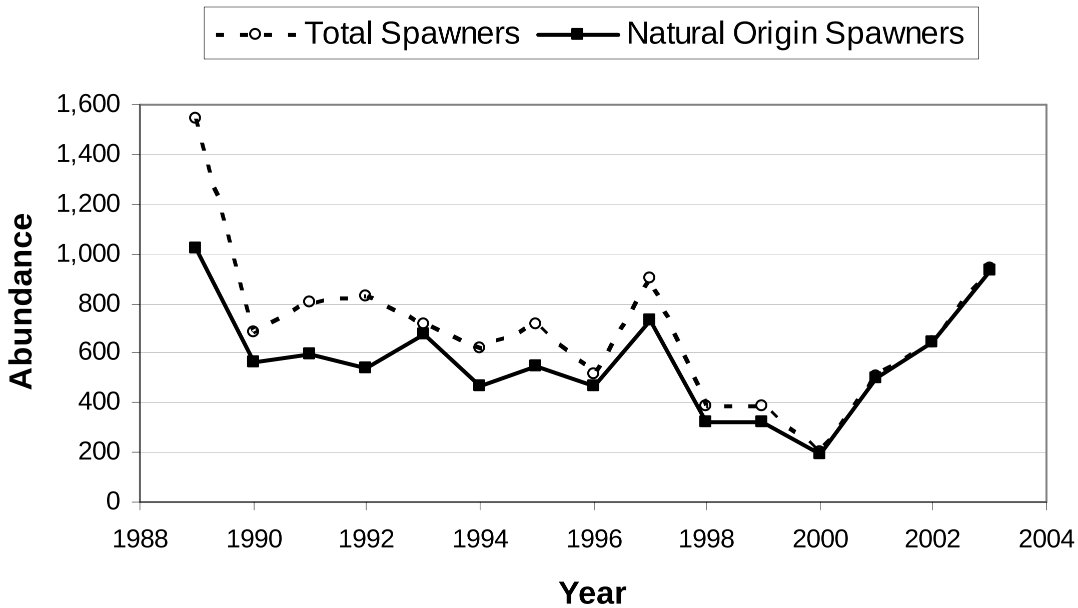


Figure B.2.4.23. Estimate of summer steelhead abundance in the Wind River.

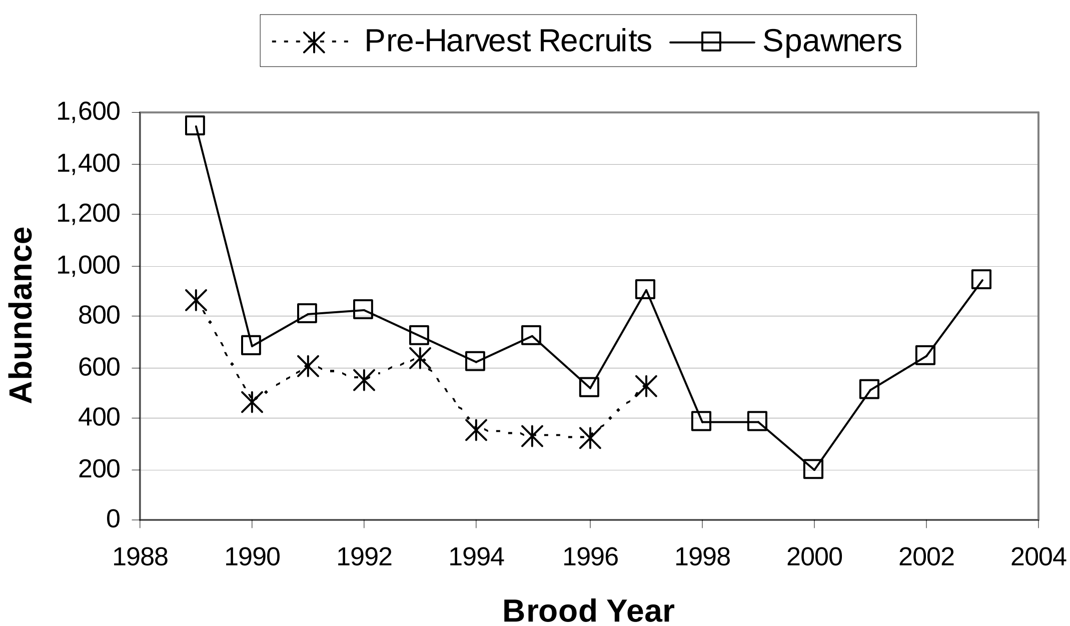


Figure B.2.4.24. Estimate of summer steelhead preharvest recruits and spawners in the Washougal River.

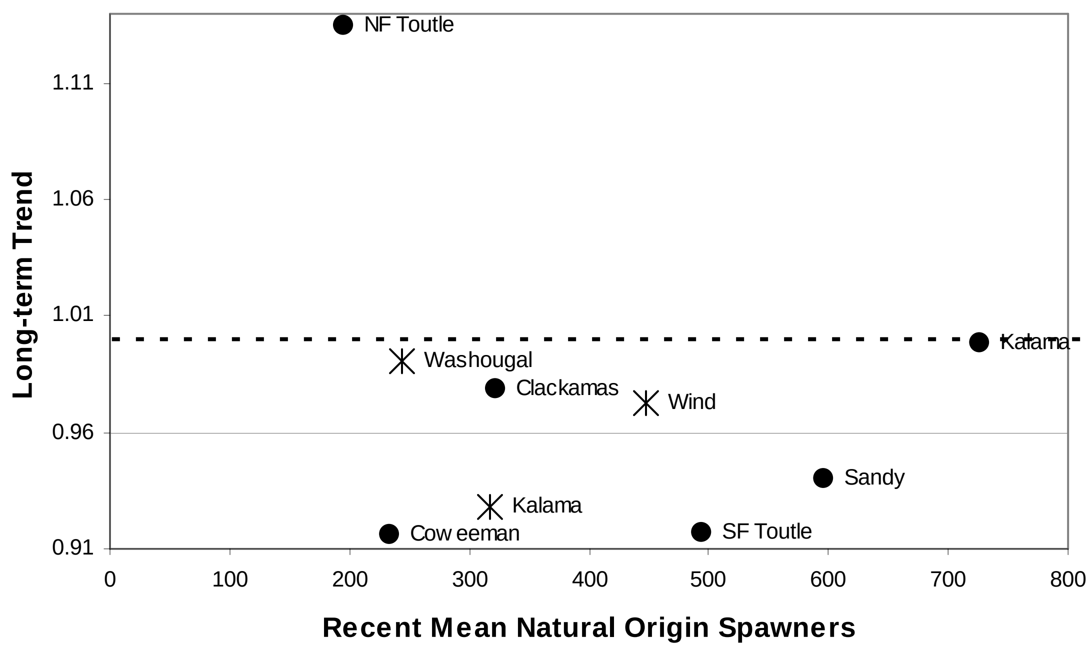


Figure B.2.4.25. Long-term trend vs. 5-year geometric mean abundance of natural-origin spawners. The "*" symbol indicates summer run populations. The dash line indicates a flat trend of 1.

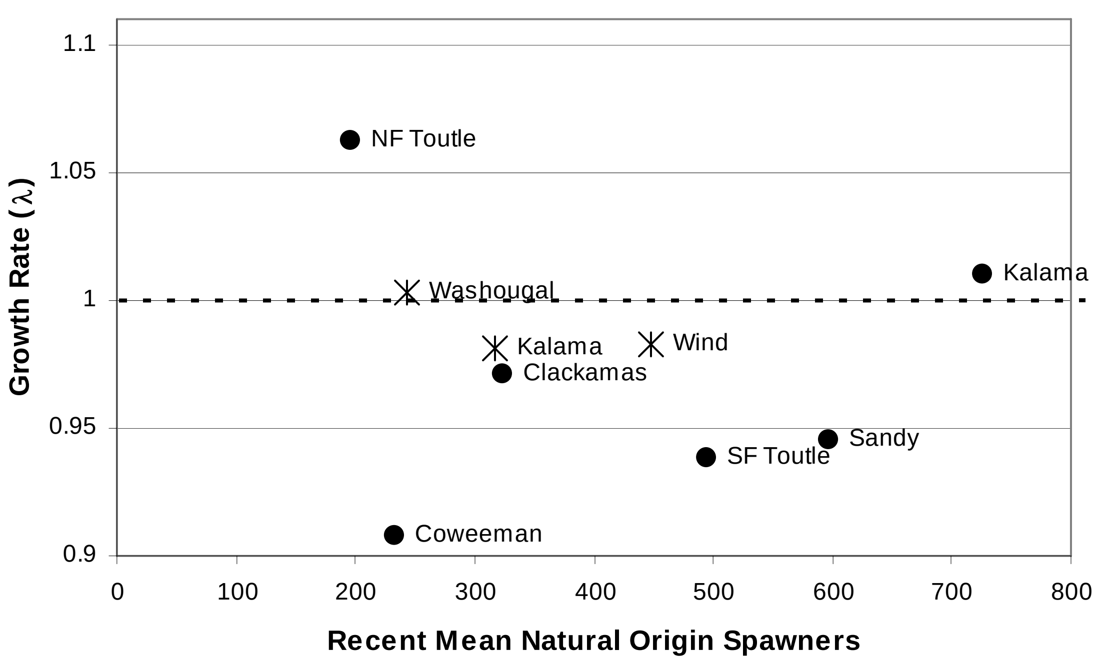


Figure B.2.4.26. Long-term growth rate vs. 5-year geometric mean abundance of natural-origin spawners. The growth rate is estimated assuming the reproductive success of hatchery-origin spawners is zero. The "*" symbol indicates summer run populations. The dash line indicates a flat trend of 1.

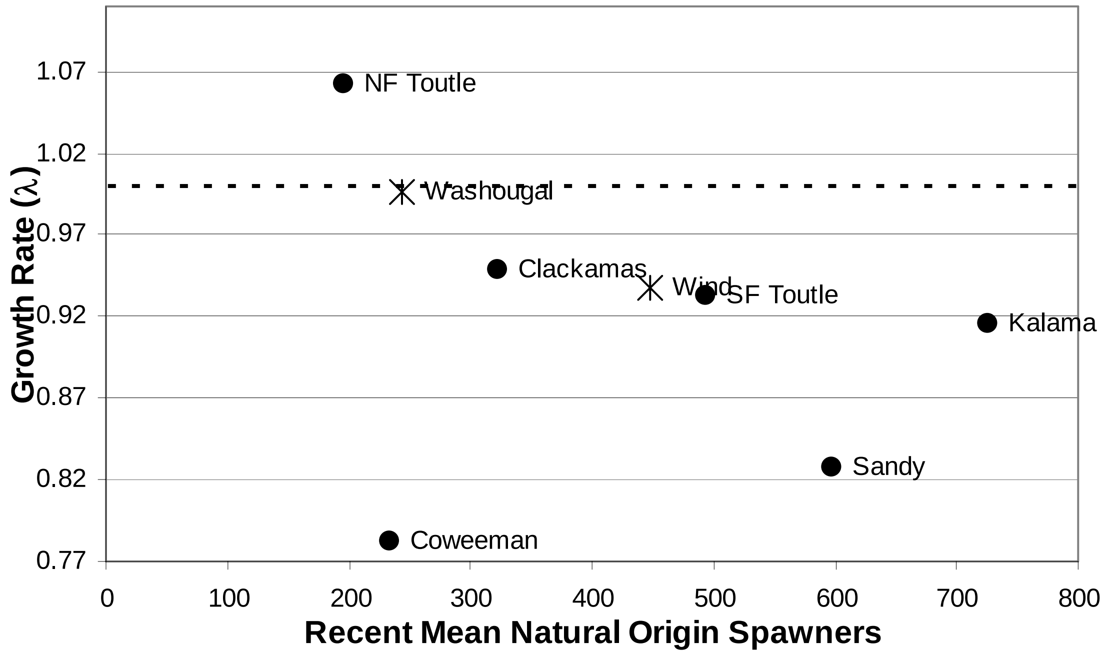


Figure B.2.4.27. Long-term growth rate vs. 5-year geometric mean abundance of natural-origin spawners. The growth rate is estimated assuming the reproductive success of hatchery-origin spawners is equivalent to that of natural-origin spawners. The "*" symbol indicates summer run populations. The dash line indicates a flat trend of 1.

B.2.5. UPPER WILLAMETTE RIVER STEELHEAD

B.2.5.1. Summary of Previous BRT Conclusions

The status of Upper Willamette River steelhead was initially reviewed by NMFS in 1996 (Busby et al. 1996) and the most recent review occur in 1999 (NMFS 1999). In the 1999 review, the BRT noted several concerns for this ESU, including the relatively low abundance and steep declines since 1988. The previous BRT was also concerned about the potential negative interaction between non-native summer steelhead and wild winter steelhead. The previous BRT considered the loss of access to historical spawning grounds because of dams a major risk factor. The 1999 BRT reached a unanimous decision that the Upper Willamette River steelhead ESU was at risk is of becoming endangered in the foreseeable future.

Current Listing Status: threatened

B.2.5.2 New Data and Updated Analyses

New data for Upper Willamette River steelhead include redd counts and dam/weir counts through 2000, 2001, or 2002 and estimates of hatchery fraction and harvest rates through 2000. New analyses for this update include the designation of demographically independent populations, and estimates of current and historically available kilometers of stream.

Results of new analyses

Historical population structure—As part of its effort to develop viability criteria for Upper Willamette River steelhead, the Willamette/Lower Columbia Technical Recovery Team (WLC-TRT) has identified historically demographically independent populations (Myers et al. 2002). Population boundaries are based on an application of Viable Salmonid Populations definition (McElhany et al. 2000). Myers et al. hypothesized that the ESU historically consisted of at least four populations (Mollala, North Santiam, South Santiam and Calapooia) and possibly a fifth (Coast Range) (Figure B.2.5.1). There is some uncertainty about the historical existence of a population in the coast range. The populations identified in Myers et al. are used as the units for the new analyses in this report.

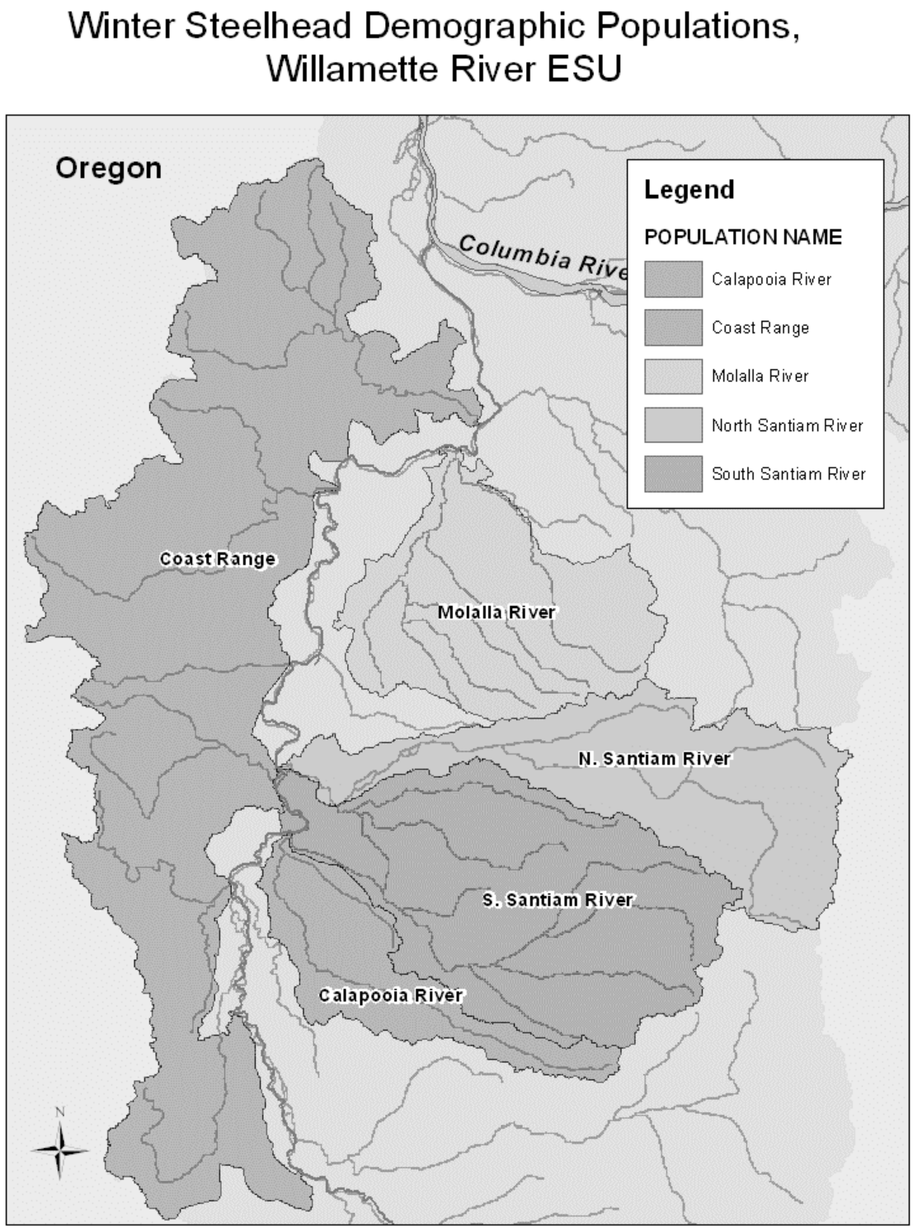


Figure B.2.5.1. Map of historical Upper Willamette River steelhead populations.

Abundance and trends

Willamette Falls - The number of winter steelhead passing over Willamette Falls from 1971 to 2002 is shown in Figure B.2.5.2. All steelhead in the ESU must pass Willamette Falls. Two groups of winter steelhead currently exist in the upper Willamette. The "late-run" winter steelhead exhibit the historical phenotype adapted to passing the seasonal barrier at Willamette Falls. The falls were laddered and hatchery "early-run" winter steelhead fish were released above the falls. The early-run fish were derived from Columbia Basin steelhead outside the Willamette and are considered non-native. The release of winter-run hatchery steelhead has recently been discontinued in the Willamette (Table B.2.5.1), but some early-run winter steelhead are still returning from the earlier hatchery releases and from any natural production of the early-run fish that has been established. One line on the graph of winter steelhead at Willamette Falls shows the combined early and late returns and the other line shows only the native late run. Non-native summer run hatchery steelhead are also released into the upper Willamette, but are not graphed. The geometric mean of late returning steelhead passing Willamette Falls over the years 1998-2002 is 5,819 steelhead and the arithmetic mean over the same period is 6,765 steelhead.

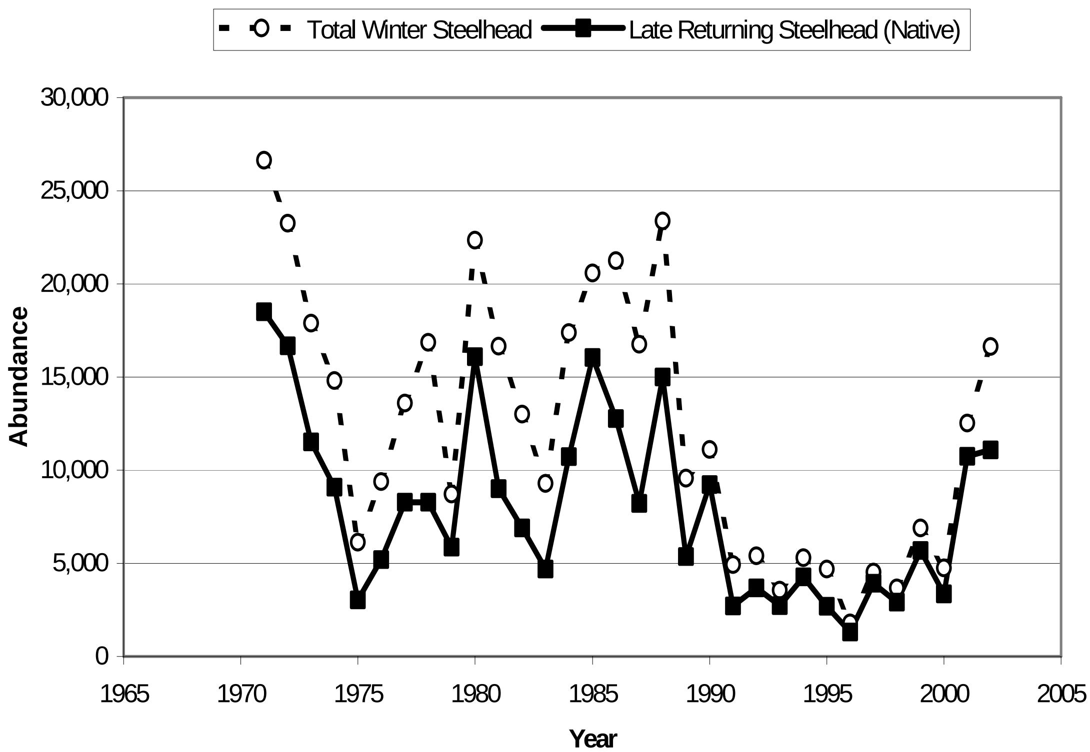


Figure B.2.5.2. Counts of winter steelhead at Willamette Falls.

Table B.2.5.1. The stocking of winter-run steelhead in the Willamette River has been discontinued. However, winter-run hatchery fish were still returning over the period of the available time series and summer run steelhead continue to be stocked in the Willamette. This table shows the last year of winter run releases in each of the basins.

Population	Last Year Winter Run Steelhead Released
Mollala River	1999
North Santiam River	1998
South Santiam River	1989
Calapooia River	No hatchery

The available time series data for individual Upper Willamette River steelhead populations consist of redd count index surveys, one dam count (Foster dam) and one hatchery trap count (Minto Trap). At one time, ODFW applied an algorithm involving the redd surveys and the length of available stream miles to apportion the fish passing Willamette Falls into individual populations. This approach appears to have been dropped in 1997 and there are currently no estimates of the absolute total numbers of spawners in the individual populations. The status of individual populations is discussed below.

Table B.2.5.2. Trends in redds per mile surveys of Upper Willamette River winter steelhead populations. The long-term trends use the entire data set and the short-term trends use data from 1990 through the most recent year. The 95% confidence intervals are in parentheses.

Population	Years of Data	Long-term Trend in Redds per Mile	Probability Long-term Trend < 1	Short-term Trend in Redds per Mile	Probability Short-term Trend < 1
Mollala	1980-2000	0.947 (0.918-0.977)	0.999	0.972 (0.867-1.090)	0.705
North Santiam	1980-2001	0.941 (0.906-0.977)	0.999	0.962 (0.845-1.095)	0.740
South Santiam	1980-2001	0.936 (0.904-0.970)	1.000	0.917 (0.811-1.037)	0.926
Calapooia	1980-2001	0.968 (0.933-1.003)	0.964	1.053 (0.935-1.149)	0.229

Molalla—A time series of redd-per-mile data from the Molalla shows a declining trend from 1980-2000 (Table B.2.5.2 and Figure B.2.5.3). Estimates of the fraction of hatchery-origin spawners for this population are shown in Figure B.2.5.9, and the estimated harvest rate in Figure B.2.5.10. The populations shows a declining trend over the available time series.

North Santiam—A time series of redd-per-mile data from the North Santiam show a declining trend from 1980-2001 (Figure B.2.5.4). A time series also exists the Minto trap on the North Santiam (Figure B.2.5.5). Minto is a hatchery acclimation-and-release site, so it is assumed that the majority of fish trapped at this site over the time series are of hatchery origin. Estimates of the fraction of hatchery-origin spawners for this population are shown in Figure B.2.5.9 and the estimated harvest rate in Figure B.2.5.10.

South Santiam—Counts of winter steelhead at Foster Dam (RKm 77) from 1967 to 2002 are shown in Figure B.2.5.6. A hatchery program was initiated in the 1980s and hatchery-origin fish were identified at the dam facility. Redd surveys are also conducted below Foster Dam (Figure B.2.5.7). Estimates of the fraction of hatchery-origin spawners for this population below Foster Dam are shown in Figure B.2.5.9, and the estimated harvest rate in Figure B.2.5.10.

Calapooia—A time series of redd-per-mile data from the Calapooia shows a declining trend from 1980-2001 (Figure B.2.5.8). Estimates of the fraction of hatchery-origin spawners for this population are shown in Figure B.2.5.9 and the estimated harvest rate in Figure B.2.5.10.

West Side Tributaries—No time series or current counts of spawner abundance for the west side tributaries population are available. It is questionable if there was ever a self-sustaining steelhead population in the west side. There is assumed to be little, if any, natural production of steelhead in these tributaries.

Loss of habitat from barriers

An analysis was conducted by Steel and Sheer (2003) to assess the number of stream km historically and currently available to salmon populations in the Upper Willamette River ESU (Table B.2.5.3). Stream km usable by salmon are determined based on simple gradient cut offs, and on the presence of impassable barriers. This approach will over estimate the number of usable stream km as it does not take into consideration habitat quality (other than gradient). However, the analysis does indicate that for some populations the number of stream habitat km currently accessible is greatly reduced from the historical condition.

Table B.2.5.3. Historical populations of Upper Willamette River spring chinook and loss of habitat from barriers. The potential current habitat is the kilometers of stream below all currently impassible barriers between a gradient of 0.5% and 4%. The potential historical habitat is the kilometers of stream below historically impassible barriers between a gradient and 0.5% and 6%. The current-to-historical habitat ratio is the percent of the historical habitat that is currently available.

Population	Potential Current Habitat (%)	Potential Historical Habitat (km)	Current to Historical Habitat Ratio
Mollala River	524	827	63
North Santiam River	210	347	61
South Santiam River	581	856	68
Calapooia River	203	318	64
West side Tributaries	1,376	2,053	67

Resident *O. mykiss* considerations

The available information on resident *O. mykiss* populations within the ESU is summarized in Table B.2.1.3 and Appendix B.5.1 and provides a broad overview of the distribution of Case 1, 2, and 3 resident populations within the ESU. See the section on Resident Fish in the Introduction section to the main body of this report for an explanation of the three cases and their relevance to ESU determinations. The section on Resident Fish in section B.1 of this steelhead report discusses how resident fish are considered in risk analyses.

Kostow (2003) has reviewed information on the abundance and distribution of resident *O. mykiss* for this ESU and found no quantitative estimates of abundance for resident *O. mykiss* in any UW population. However, expert opinion indicates that resident *O. mykiss* are rare in this ESU. Cutthroat trout (*Oncorhynchus clarki)* are found through much of the Willamette River Basin and tend not to co-occur with resident *O. mykiss*. Resident *O. mykiss* in the Middle Fork Willamette and McKenzie River might normally be considered to be Case 1 because there are no obvious barriers to anadromous access to these areas. Nevertheless, there is no evidence that steelhead historically inhabited these basins, and the resident fish in these basins are morphologically distinctive (being known locally as “McKenzie redsides; Kostow 2003). These upper basin resident fish are also genetically quite different from Upper Willamette ESU steelhead (NMFS unpublished data), and they are not considered part of the Upper Willamette River ESU (cite FR notice; status review or update memo)

Resident or residualized rainbow trout are found above the dams on the North and South Santiam Rivers; historically, these areas were the primary production areas for steelhead in this ESU. We are not aware of specific information relevant to the ESU status of these Case 3 resident populations. Resident *O. mykiss* are found in the numerous small waterfalls that exist in the headwater regions of this ESU.

B.2.5.3. ESU Summary

Based on the updated information provided in this report, the information contained in previous Upper Willamette River steelhead ESU status reviews, and preliminary analyses by the WLC-TRT, we could not conclusively identify a single population that is naturally self-sustaining. All populations are relatively small, with the recent mean abundance of the entire ESU at less than 6,000. Over the period of the available time series, most of the populations are in decline. The recent elimination of the winter-run hatchery production will allow estimation of the naturally productivity of the populations in the future, but the available time series are confounded by the presence of hatchery-origin spawners. On a positive note, the counts all indicate an increase in abundance in 2001, likely at least partly as a result of improved marine conditions. The issue of changing marine conditions is discussed in the introduction to this update report, as it is an issue for may ESUs.

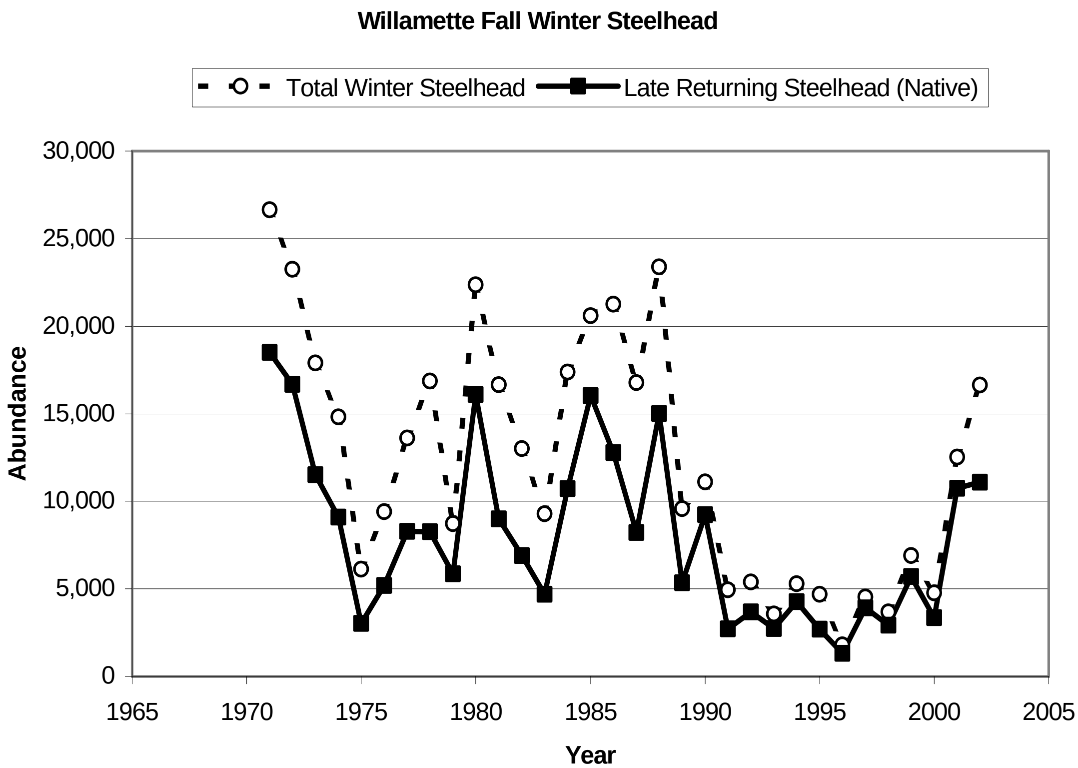


Figure B.2.5.2. Counts of winter steelhead at Willamette Falls.

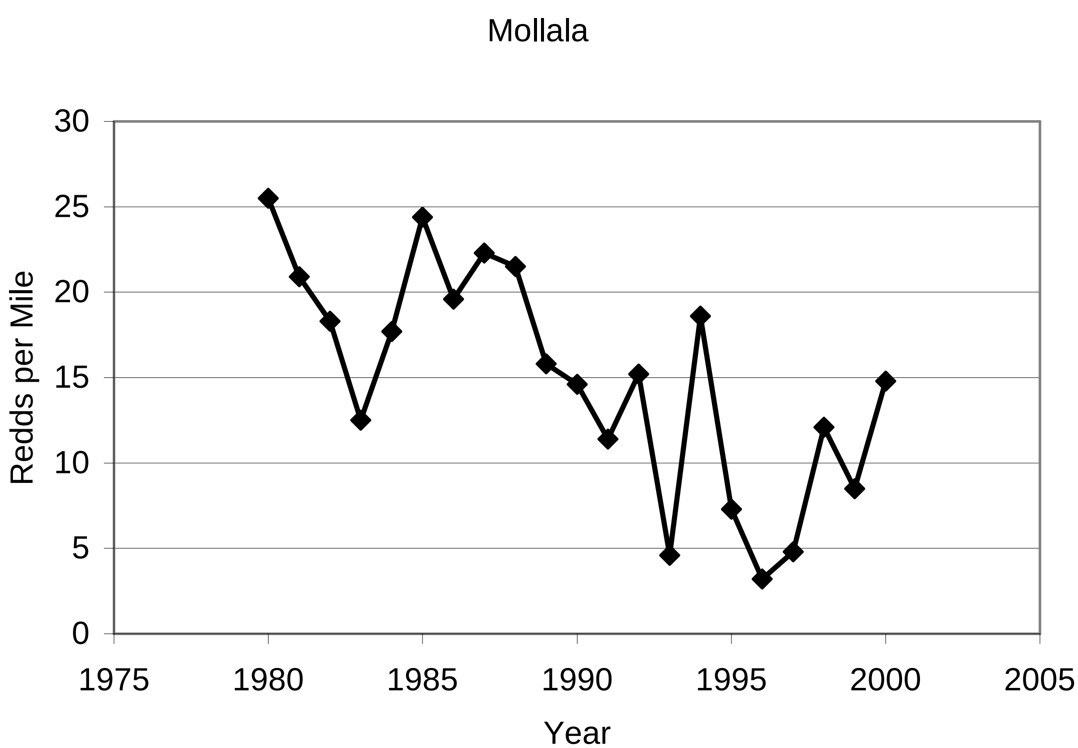


Figure B.2.5.3. Redd surveys of winter steelhead in the Molalla.

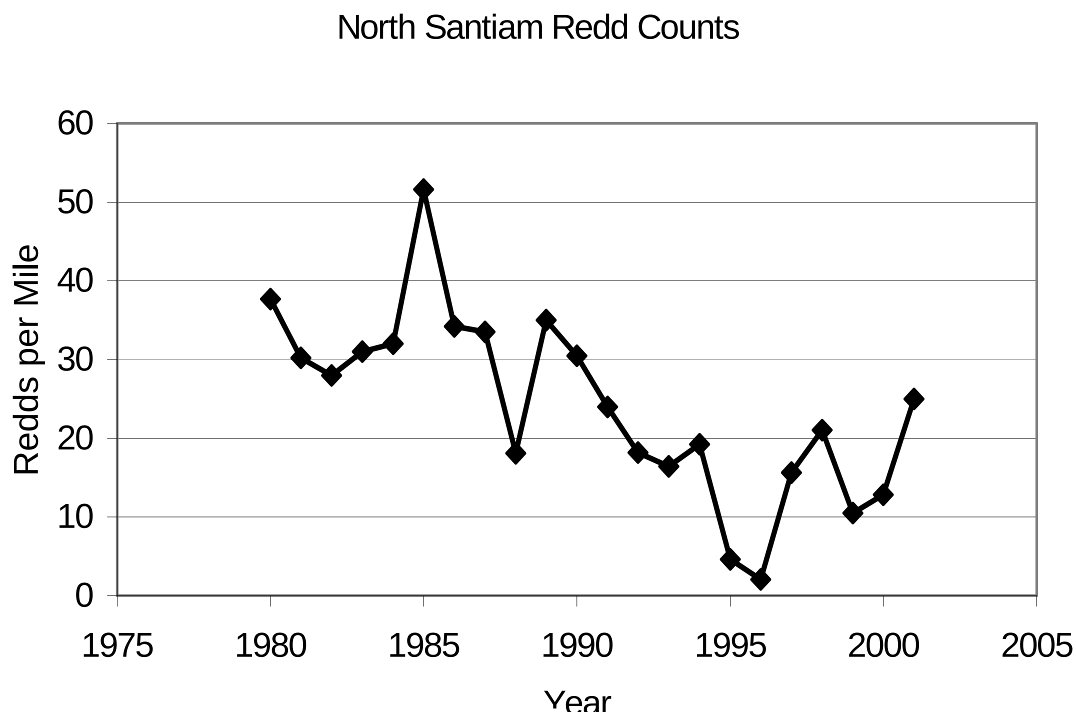


Figure B.2.5.4. Redd surveys of winter steelhead in the North Santiam.

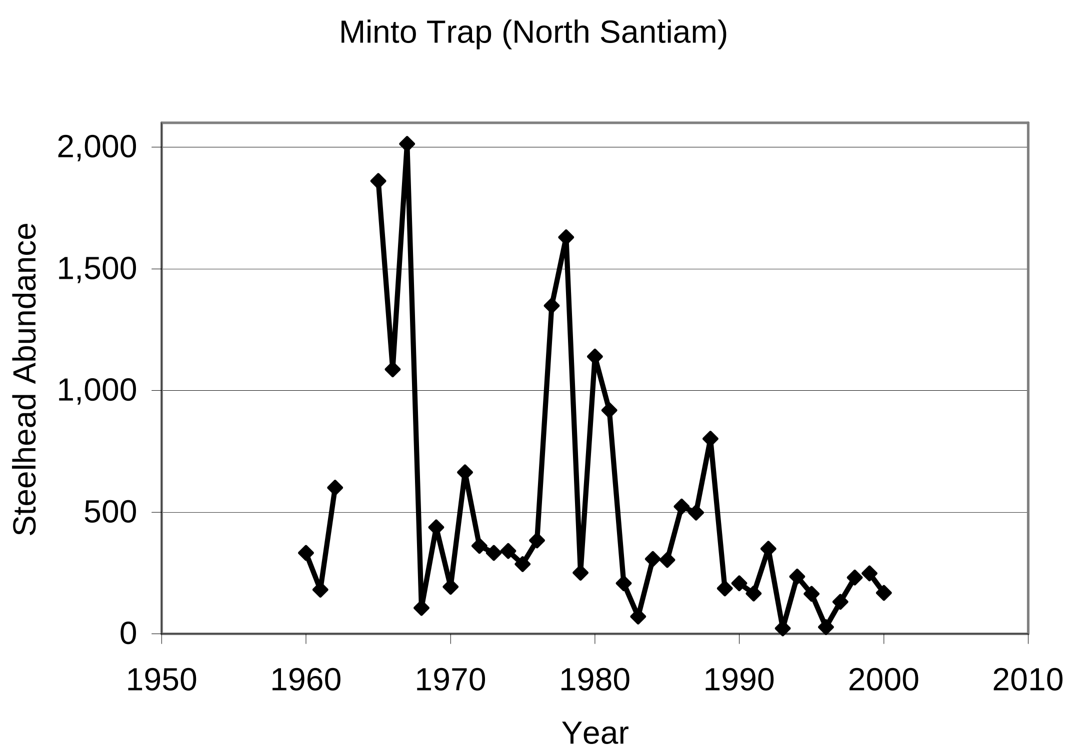
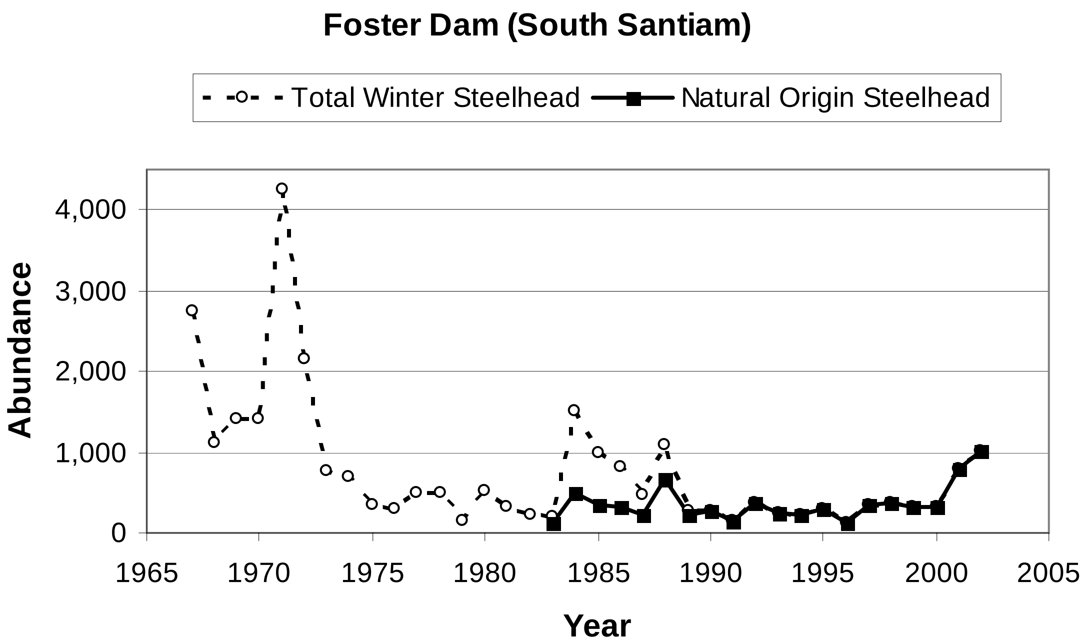


Figure B.2.5.5. Counts of winter steelhead at the Minto trap on the North Santiam. Minto is a hatchery-acclimation pond and release site.



B.2.5.6. Counts of winter steelhead at Foster Dam on the South Santiam (RKm 77).

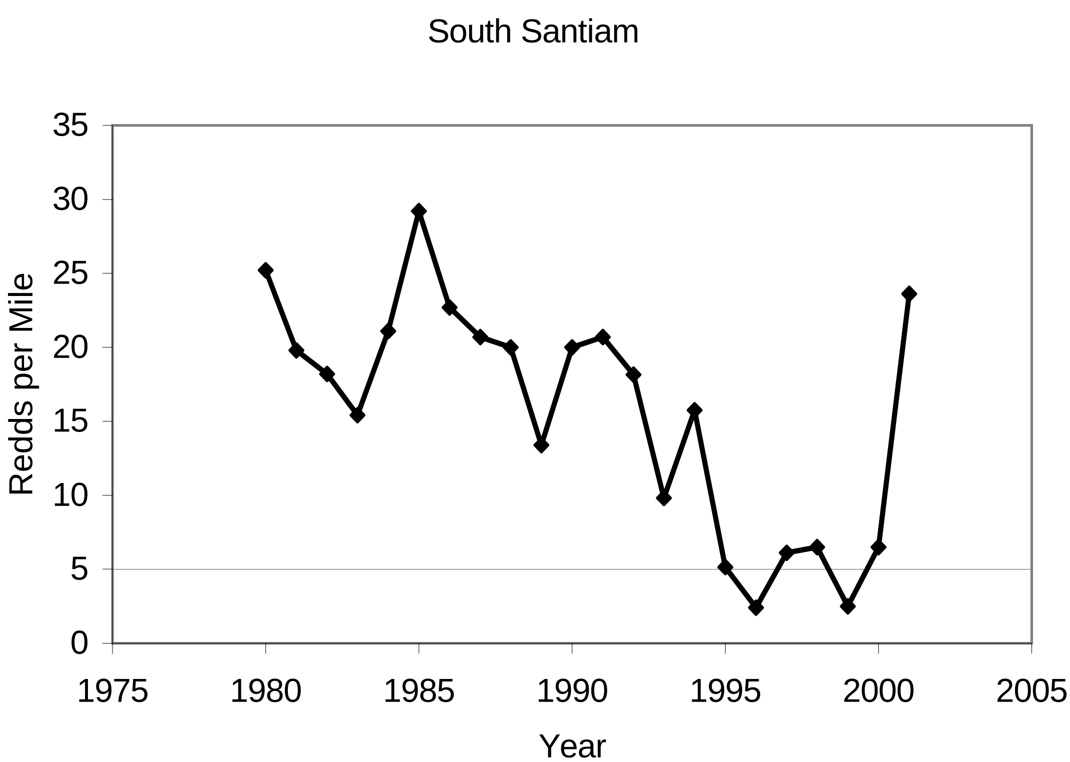


Figure B.2.5.7. Redd surveys of winter steelhead in the South Santiam below Foster Dam.

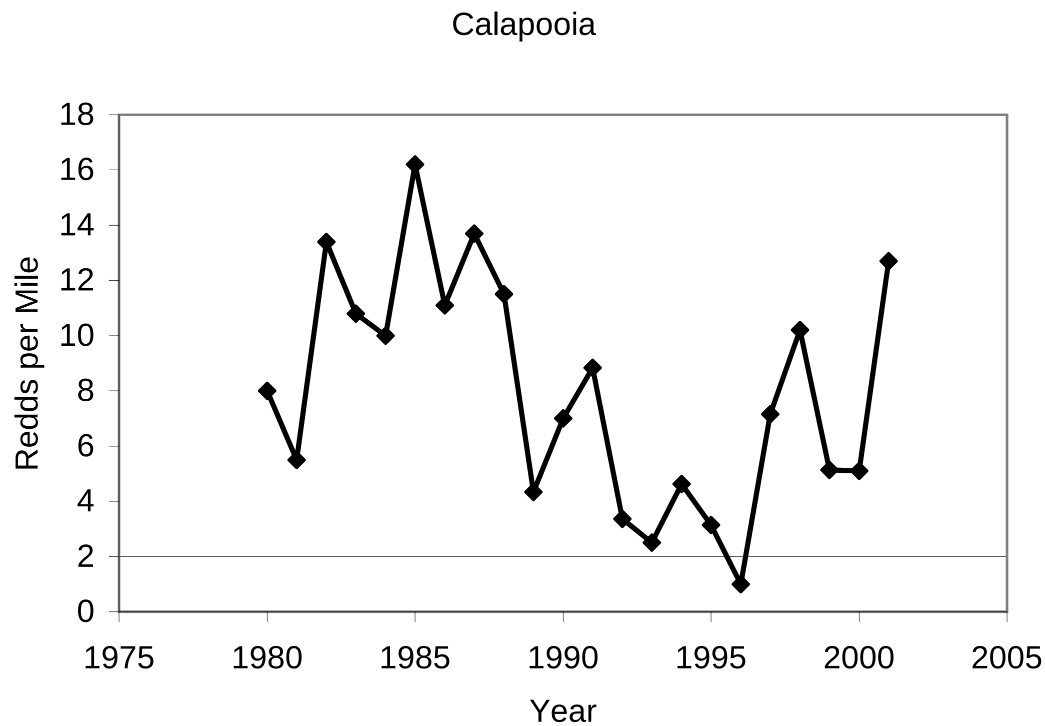


Figure B.2.5.8. Redd surveys of winter steelhead in the Calapooia River.

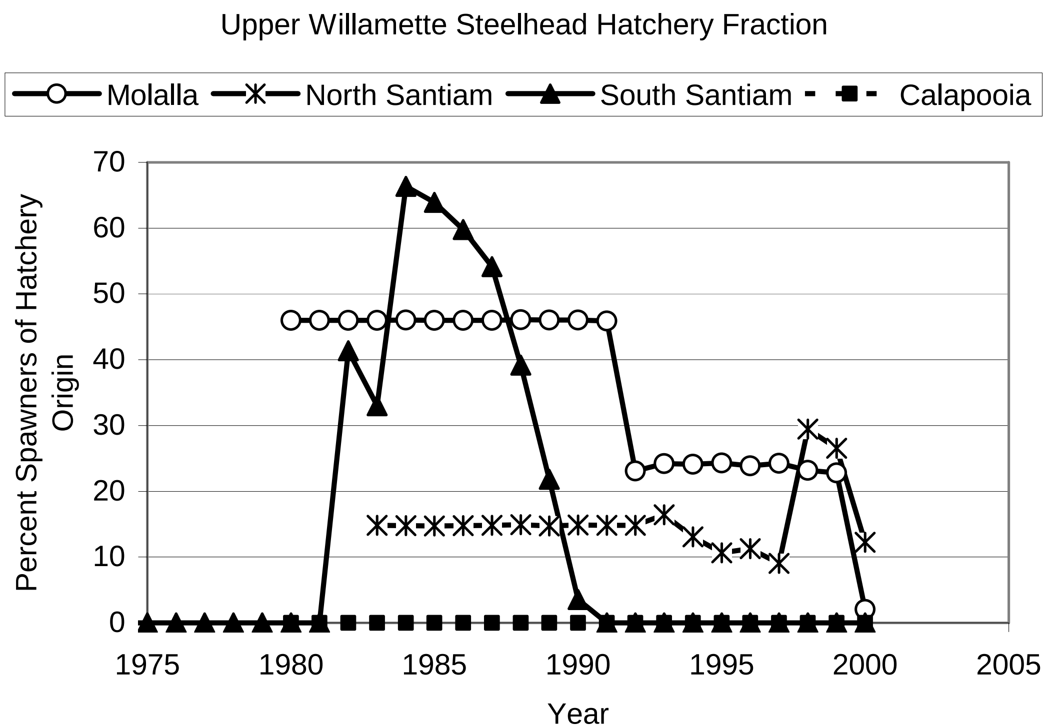


Figure B.2.5.9. Estimates of the fraction of hatchery-origin spawners in populations of UW winter steelhead (Chilcote 2001). Winter steelhead are not currently released into the UW.

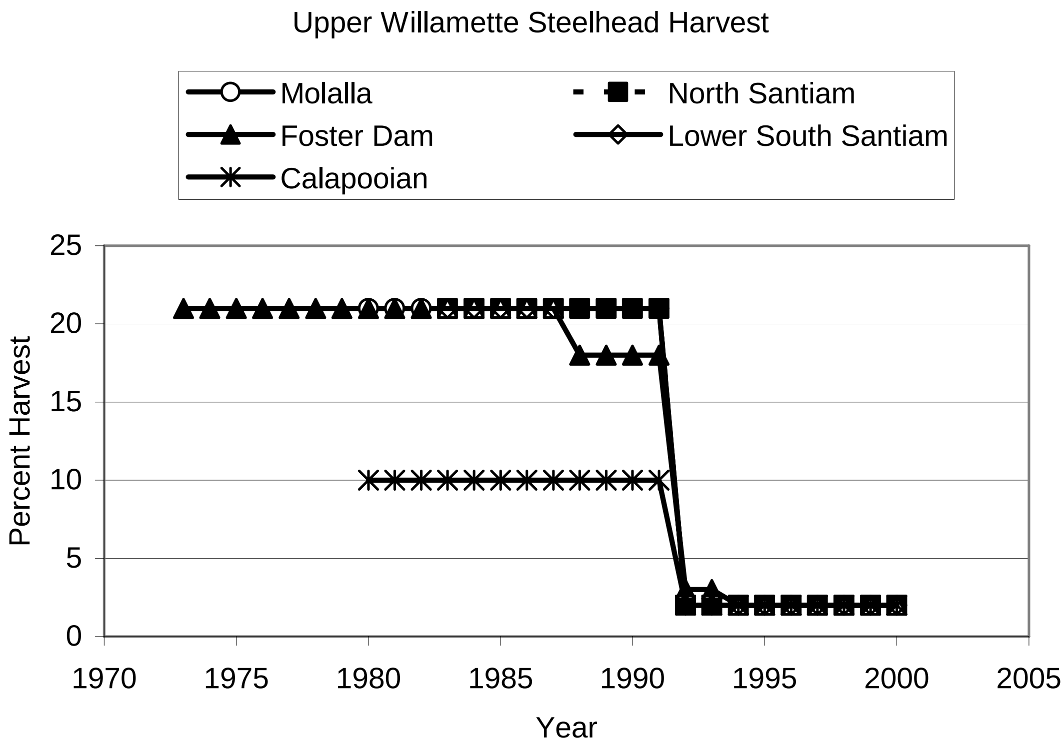


Figure B.2.10. Estimates of the harvest rate on populations of UW winter steelhead (Chilcote 2001).

B.2.6 NORTHERN CALIFORNIA STEELHEAD ESU

Primary contributor: David Boughton

(Southwest Fisheries Science Center – Santa Cruz Lab)

B.2.6.1 Summary of Previous BRT Conclusions

The Northern California ESU was determined to inhabit coastal basins from Redwood Creek (Humboldt County) southward to the Gualala River (Mendocino County), inclusive (Busby et al. 1996). Within this ESU, both summer-run[2], winter-run, and half-pounders[3] have been found. Summer-run steelhead are found in the Mad, Eel, and Redwood rivers; the Middle Fork Eel River population is their southern-most occurrence. Half-pounders are found in the Mad and Eel rivers. Busby et al. (1996) argued that when summer-run and winter-run steelhead co-occur within a basin, they were more similar to each other than either is to the corresponding run-type in other basins. Thus Busby et al. (1996) considered summer-run and winter-run steelhead to jointly comprise a single ESU.

Summary of major risks and status indicators

Risks and limiting factors—The previous status review (Busby et al. 1996) identified two major barriers to fish passage: Mathews Dam on the Mad River and Scott Dam on the Eel River. Numerous other blockages on tributaries were also thought to occur. Poor forest practices and poor land use practices, combined with catastrophic flooding in 1964, were thought to have caused significant declines in habitat quality that then persisted up to the date of the status review. These effects include sedimentation and loss of spawning gravels. Non-native Sacramento pikeminnow (*Ptychocheilus grandis*) had been observed in the Eel River basin and could be acting as predators on juvenile steelhead, depending on thermal conditions leading to niche overlap of the two species (see also Brown and Moyle 1981, 1997; Harvey et al 2002, Reese and Harvey 2002).

Status indicators—Historical estimates (pre-1960s) of steelhead abundance for this ESU have been few (Table B.2.6.1). The only time-series data are dam counts of winter-run steelhead in the upper Eel River (Cape Horn Dam, 1933-present), winter-run steelhead in the Mad River (Sweasey Dam, 1938-1963), and combined counts of summer-run and winter-run steelhead in the South Fork Eel River (Benbow Dam, 1938-75; see Figure B.2.6.1A). More recent data are snorkel counts of summer-run steelhead that were made in the middle fork of the Eel since 1966 (with some gaps in the time-series) (Scott Harris and Wendy Jones, CDFG, personal communication). Some "point" estimates of mean abundance exist—in 1963, the California

---

[2] Some consider summer-run steelhead and fall-run steelhead to be separate runs within a river while others do not consider these groups to be different. For purposes of this review, summer-run and fall-run are considered stream-maturing steelhead and will be referred to as summer steelhead (see McEwan 2001 for additional details).

[3] A half pounder is a sexually immature steelhead, usually small, that returns to freshwater after spending less than a year in the ocean (Kesner and Barnhart 1972, Everest 1973).

Department of Fish and Game made estimates of steelhead abundance for many rivers in the ESU (Table B.2.6.2). An attempt was made to estimate a mean count over the interval 1959 to 1963, but in most cases 5 years of data were not available and estimates were based on fewer years (CDFG 1965); the authors state that "estimates given here which are based on little or no data should be used only in outlining the major and critical factors of the resource" (CDFG 1965). The previous BRT (Busby et al. 1996) considered the above datasets in making their risk assessment.

Table B.2.6.1. Summary of historical abundance (average counts) for steelhead in the Northern California evolutionarily significant unit (see also Figure 1).

		Average count						
Basin	**Site**	**1930s**	**1940s**	**1950s**	**1960s**	**1970s**	**1980s**	**Reference**
Eel River	Cape Horn Dam	4,390	4,320	3,597	917	721	1,287	Grass 1995
Eel River	Benbow Dam	13,736	18,285	12,802	6,676	3,355	-	
Mad River	Sweasey Dam	3,167	4,720	2,894	1,985	-	-	

Although the data were relatively few, the data that did exist suggested the following to the BRT: 1) Population abundances were low relative to historical estimates (1930s dam counts; see Table B.2.6.1 and Figure B.2.6.1); 2) Recent trends were downward (except for a few small summer-run stocks; see Figures B.2.6.1 and B.2.6.2); and 3) Summer-run steelhead abundance was "very low." The BRT was also concerned about negative influences of hatchery stocks, especially in the Mad River (Busby et al. 1996). Finally, the BRT noted that the status review included two major sources of uncertainty: lack of data on run sizes throughout the ESU, and uncertainty about the genetic heritage of winter-run steelhead in Mad River.

Listing status

Status was formally assessed in 1996 (Busby et al. 1996), updated in 1997 (NMFS 1997) and updated again in 2000 (Adams 2000). Although other steelhead ESUs were listed as threatened or endangered in August 1997, the National Marine Fisheries Service (NMFS) allowed steelhead in the Northern California ESU to remain a candidate species pending an evaluation of state and federal conservation measures. There was a "North Coast Steelhead Memorandum of Agreement" (MOA) with the State of California, which listed a number of proposed actions, including a change in harvest regulations, a review of California hatchery practices, implementation of habitat restoration activities, implementation of a comprehensive monitoring program, and numerous revisions to rules on forest-practices. These revisions would be expected to improve forest condition on non-federal lands. In March 1998 the NMFS announced its intention to reconsider the previous no-listing decision. On 6 October 1999 the California Board of Forestry failed to take action on the forest practice rules, and the NMFS Southwest Region (SWR) regarded this failure as a breach of the MOA, despite the fact that other state agencies, such as the California Department of Fish and Game, had complied with the MOA. The Northern California ESU was listed as threatened in June 2000.

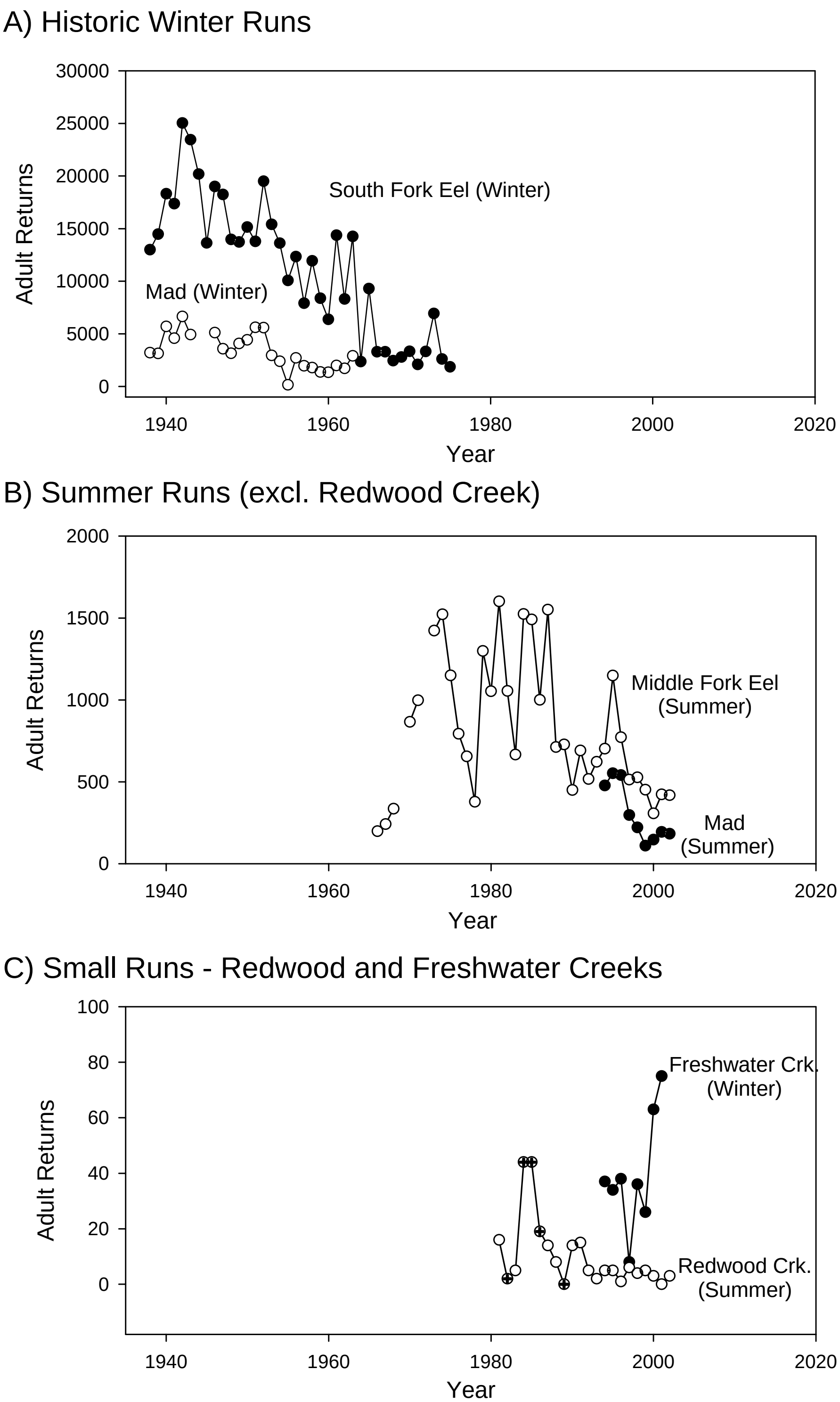


Figure B.2.6.1. Time-series data for the North-Central California Steelhead ESU. A) Historical data from winter runs on the Mad River and South Fork Eel. B) Summer-run on the Middle Fork Eel and Mad River. C) Summer-run steelhead in Redwood Creek, and winter-run steelhead in Freshwater Creek, Humboldt County. Symbols with crosses represent minimum estimates. Note the three different scales of the *y*-axis.

Table B.2.6.2. Historical estimates of number of spawning steelhead for California rivers in the Northern California ESU and Central California Coast ESU (data from CDFG 1965). Estimates are considered by CDFG (1965) to be notably uncertain.

ESU	Stream	1963
Northern California		
	Redwood Creek	10,000
	Mad River	6,000
	Eel River (total)	82,000
	Eel River	(10,000)
	Van Duzen River (Eel)	(10,000)
	South Fork Eel River	(34,000)
	North Fork Eel River	(5,000)
	Middle Fork Eel River	(23,000)
	Mattole River	12,000
	Ten Mile River	9,000
	Novo River	8,000
	Big River	12,000
	Navarro River	16,000
	Garcia River	4,000
	Gualala River	16,000
	other Humboldt County stream	3,000
	other Mendocino County streams	20,000
	Total	198,000
Central California Coast		
	Russian River	50,000
	San Lorenzo River	19,000
	other Sonoma County streams	4,000
	other Marin County steams	8,000
	other San Mateo County streams	8,000
	other Santa Cruz County streams	5,000
	Total	94,000

B.2.6.2 New Data and Updated Analyses

There are four significant sets of new information regarding status: 1) Updated time-series data exist for the middle fork of the Eel River (summer-run steelhead; snorkel counts. See Figure B.2.6.1B); 2) There are new data-collection efforts initiated in 1994 in the Mad River (summer-run steelhead; snorkel counts--Figure B.2.6.1B) and in Freshwater Creek (winter-run steelhead; weir counts--Figure B.2.6.1C; Freshwater Creek is a small stream emptying into Humboldt Bay; 3) Numerous reach-scale estimates of juvenile abundance have been made extensively throughout the ESU; and 4) Harvest regulations have been substantially changed since the last status review. Analyses of this information are described below.

Updated Eel River data

The time-series data for the Middle Fork of the Eel River are snorkel counts of summer-run steelhead, made for fish in the holding pools of the entire mainstem of the middle fork (Scott Harris and Wendy Jones, CDFG, pers. comm.). Most adults in the system are thought to oversummer in these holding pools. An estimate of λ over the interval 1966 to 2002 was made using the method of Lindley (in press; random-walk-with-drift model fitted using Bayesian assumptions). The estimate of λ is 0.98, with a 95% confidence interval of [0.93, 1.04] (see Table B.2.6.3)[4]. The overall trend in the data is downward in both the long- and the short-term (Figure B.2.6.1B).

New time-series

The Mad River time-series consists of snorkel counts for much of the mainstem below Ruth Dam. Some counts include the entire mainstem; other years include only data from land owned by Simpson Timber Company. In the years with data from the entire mainstem, fish from Simpson Timber land make up at least 90% of the total count. The time-series from Freshwater Creek is composed of weir counts. Estimates of λ were not made for either time-series because there were too few years of data to make meaningful estimates.

Vital statistics for these and other existing time-series are given in Table B.2.6.3; trend versus abundance is plotted in Figure B.2.6.2.

[4] Note that Lindley (in press) defines $\lambda \approx \exp(\mu + \sigma^2/2)$, whereas Holmes (2001) defines $\lambda \approx \exp(\mu)$; see the Lindley (in press) for meaning of the symbols.

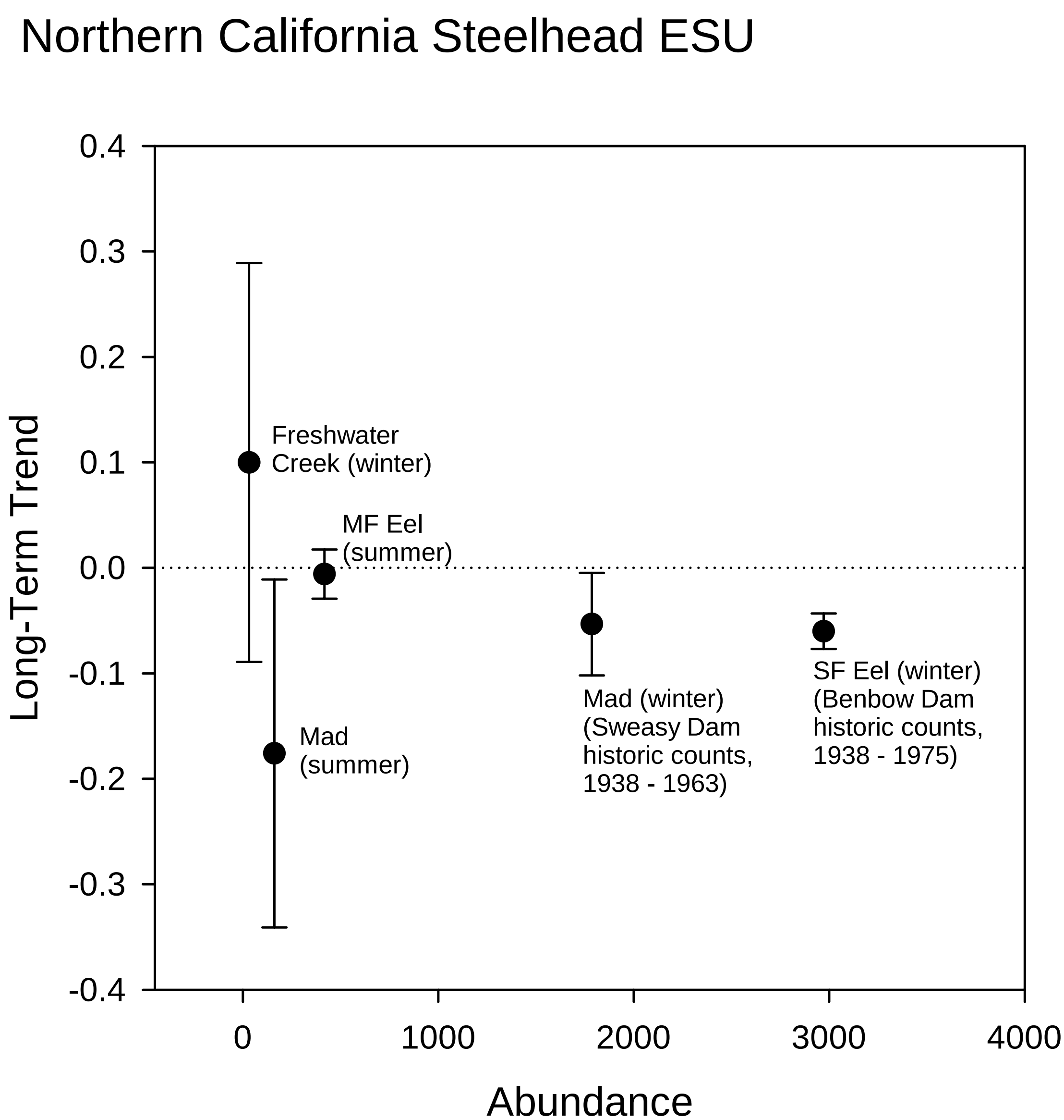


Figure B.2.6.2. Trends versus abundance for the time-series data from Figure B.2.6.1. Note that neither set of dam counts (Sweasy Dam, Benbow Dam) has any recent data. Vertical bars are 95% confidence intervals.

Table B.2.6.3. Summary of time-series data for listed steelhead ESUs on the California Coast.

Population	Span of time series	5-Year Means[5]			Lambda[6]	Long-term trend	Short-term trend (95% conf. int.)
		Rec.	Min.	Max.		(95% conf. int.)	
Northern California ESU (threatened)							
M.Fk. Eel Riv. (summer-run)	’66-’02	418	384	1,246	0.98 (0.93, 1.04)	-0.006 (-0.029, 0.017)	-0.067 (-0.158, 0.024)
Mad River (summer-run)	’94-’02	162	162	384	Insufficient data	-0.176 (-0.341, -0.012)	-0.176 (-0.341, -0.121)
Freshwater Crk. (winter-run)	’94-’01	32	25	32	Insufficient data	0.099 (-0.289, 0.489)	0.099 (-0.289, 0.489)
Redwood Crk. (summer-run)	’81-’02	3	Fig. B.2.6.1[7]		Insufficient data	See Fig. B.2.6.1	-0.775 (-1.276, -0.273)
S.Fk. Eel Riv. (winter-run)[8]	’38-’75		2,743	20,657	0.98 (0.92, 1.02)	-0.060 (-0.077, -0.043)	No recent data
Mad Riv. (winter-run)[9]	’38-’63		1,140	5,438	1.00 (0.93, 1.05)	-0.053 (-0.102, -0.005)	No recent data
Central California ESU (threatened)							
No data							
South-Central California ESU (threatened)							
Carmel River (winter-run)	’62-’02	611	1.13	881	Insufficient data	0.488 (0.442, 0.538)[10]	0.488 (0.442, 0.538)
Southern California ESU (endangered)							
Santa Clara R. (winter-run)[11]	’94-’97	1.0			Insufficient data		

[5] Geometric means. The value 0.5 was used for years in which the count was zero.
[6] Lambda calculated using the method of Lindley (In press). Note that a population with lambda greater than 1.0 can nevertheless be declining, due to environmental stochasticity.
[7] Certain years have minimum run sizes, rather than unbiased estimates of run size, rendering the time series unsuitable for some of the estimators.
[8] Historical counts made at Benbow Dam.
[9] Historical counts made at Sweasy Dam.
[10] Early data (pre 1988) have exceptionally high observation error and were not used in calculations.
[11] Recent abundance is a 4-year mean.

Juvenile data

Data on juvenile abundance were collected at numerous sites using a variety of methods (contact NMFS SW Fisheries Science Ctr. for attributions of datasets). Many of the methods involve the selection of reaches thought to be "typical" or "representative" steelhead habitat; other reaches were selected because they were thought to be typical coho habitat, and steelhead counts were made incidentally to coho counts. In general, the field crew made electro-fishing counts (usually multiple-pass, depletion estimates) of the young-of-the-year and 1+ age classes. Most of the target reaches got sampled several years in a row; thus there are a large number of short time-series. Although methods were always consistent within a time-series, they were not necessarily consistent across time-series.

Because there are so few adult data on which to base a risk assessment of this ESU, we chose to analyze these juvenile data. However, we note that they have limited usefulness for understanding the status of the adult population, due to non-random sampling of reaches within stream systems; non-random sampling of populations within the ESU; and a general lack of estimators shown to be robust for estimating fish density within a reach. In addition, even if more rigorous methods had been used, there is no simple relationship between juvenile numbers and adult numbers (Shea and Mangel 2001), the latter being the usual currency for status reviews. Table B.2.6.4 describes the various possible ways that one might translate juvenile trends into inferences about adult trends.

To estimate a trend from the juvenile data, the data within each time-series were log-transformed and then normalized, so that each datum represented a deviation from the mean of that specific time-series. The normalization is intended to prevent spurious trends that could arise from the diverse set of methods used to collect the data. Then, the time-series were grouped into units thought to plausibly represent independent populations; the grouping was based on watershed structure. Finally, within each population a linear regression was done for the mean deviation versus year. The estimator for time-trend within each grouping is the slope of the regression line. The minimum number of observations per time-series is 6 years (Other assessments in this status review place the cut-off at 10 years.). The general lack of data on this ESU prompted us to consider these datasets despite their brevity.

This procedure resulted in 10 independent populations for which a trend was estimated. Both upward and downward trends were observed (Figure B.2.6.3). We tested the null hypothesis that abundances were stable or increasing. It was not rejected (H_o: slope ≥ 0; $p < 0.32$ via one-tailed *t*-test against expected value). However, it is important to note that a significance level of 0.32 implies a probability of 0.32 that the ESU is stable or increasing, and a probability of $1 - 0.32 = 0.68$ that the ESU is declining; thus the odds are more than 2:1 that the ESU has been declining during the past 6 years. This conclusion requires the assumption that the assessed populations 1) are indeed independent populations rather than plausibly independent populations, and 2) were randomly sampled from all populations in the ESU (in fact they were "haphazardly" sampled).

Table B.2.6.4. Interpretation of data on juvenile trends.

		Inference made about adult trends		
		Increasing	**Level**	**Decreasing**
Observed juvenile trends	Increasing	Possible, if no density-dependence in the smolt/oceanic phase. The most parsimonious inference.	Possible, if density-dependence occurs in the juvenile over-wintering phase, or in the smolt/oceanic phase.	Possible, if oceanic conditions are deteriorating markedly at the same time that reproductive success per female is improving.
	Level	Possible, if oceanic conditions are improving for adults, but juveniles undergo density-dependence.	Possible. The most parsimonious inference.	Possible, if oceanic conditions are deteriorating.
	Decreasing	Unlikely, but could happen over the short term due to scramble competition at the spawning/redd phases.	Possible, if river habitat is deteriorating, and there was strong, pre-existing density dependence in the oceanic phase.	Likely. The most parsimonious inference.

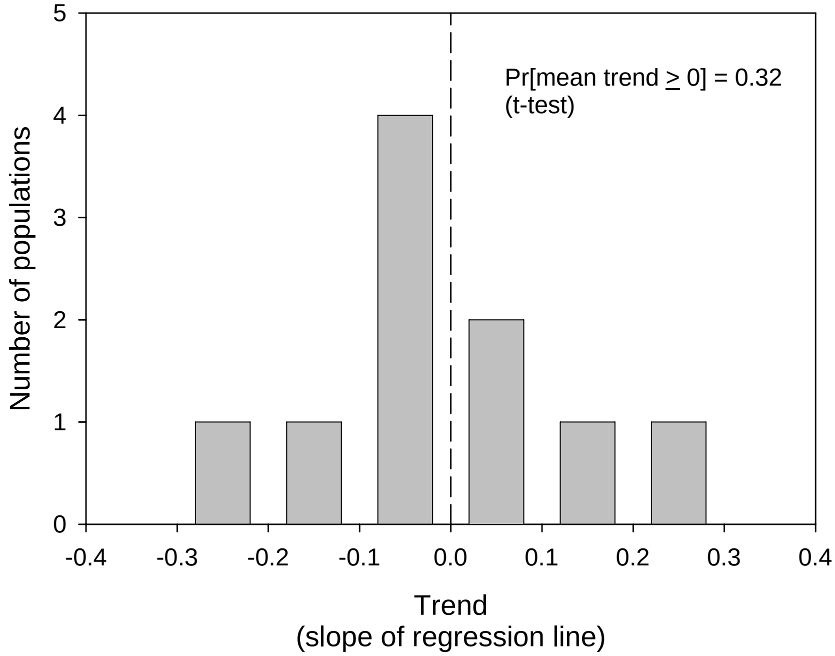


Figure B.2.6.3. Distribution of trends in juvenile density, for 10 "independent" populations within the North Coast steelhead ESU (see text for description of methods). Trend is measured as the slope of a regression line through a time-series; values less than zero indicate decline; values greater than zero indicate increase. Assuming that the populations were randomly drawn from the ESU as a whole, the hypothesis that the ESU is stable or increasing cannot be statistically rejected (p = 0.32), but is only half as likely as the hypothesis that the ESU is declining (p = 1 – 0.32 = 0.68).

Possible changes in harvest impacts

Since the original status review of Busby et al. (1996), regulations concerning sport fishing have been changed in a way that probably reduces extinction risk for the ESU.

Sport harvest in the ocean is prohibited by the California Department of Fish and Game (CDFG 2002a), and ocean harvest is a rare event (M. Mohr, NMFS, pers. comm.), so effects on extinction risk are negligible. For freshwaters (CDFG 2002b), all streams are closed to fishing year round except for special listed streams as follows: Catch-and-release angling is allowed year round excluding April and May in the lower mainstem of many coastal streams. Most of these have a bag limit of one hatchery trout or steelhead during the winter months (Albion River, Alder Creek, Big River, Cottoneva Creek, Elk Creek, Elk River, Freshwater Creek, Garcia River, Greenwood Creek, Little River in Humboldt Co., Gualala River, Navarro River, Noyo River, Ten Mile River, and Usal Creek); in a few the one-fish bag limit extends to the entire season (Bear River and Redwood Creek, both in Humboldt Co.). The Mattole River has a slightly more restricted catch-and-release season with zero bag limit year round.

The two largest systems are the Mad River and Eel River. The mainstem Mad River is open except for April and May over a very long stretch; bag limit is two hatchery trout or steelhead; other stretches have zero bag limit or are closed to fishing. Above Ruth Dam, an impassable barrier, the bag limit is five trout per day. The Eel River's mainstem and south fork are open to catch-and-release over large stretches, year round in some areas and closed April and May in others. The middle fork is open for catch and release except mid summer and late fall/winter. In the upper middle fork and many of its tributaries, there are summer fisheries with bag limits of two or five fish with no stipulated restriction on hatchery or wild. In the Van Duzen, a major tributary of the mainstem Eel, there is a summer fishery with bag limit five above Eaton Falls (CDFG 2002c). Elsewhere, some summer trout fishing is allowed, generally with a two- or five- bag limit. Cutthroat trout have a bag limit of two from a few coastal lagoons or estuaries.

At catch-and-release streams, all wild steelhead must be released unharmed. There are significant restrictions on gear used for angling. The CDFG monitors angling effort and catch-per-unit-effort in selected basins by way of a "report card" system in which sport anglers self-report their catch, gear used, and so forth, and in selected other basins by way of creel censuses.

Although the closure of many areas, and institution of catch-and-release elsewhere, is expected to reduce extinction risk for the ESU, this risk reduction cannot be estimated with existing data (due to the fact that natural abundance is not being estimated). After the Federal listing decisions, NMFS requested that CDFG prepare a Fishery Management and Evaluation Plan (FMEP) for the listed steelhead ESUs in California. This has not yet been done for the northern California ESU.

Resident *O. mykiss* considerations

Resident (non-anadromous) populations of *O. mykiss* were assigned to one of three categories for the purpose of provisionally determining ESU membership (See "Resident Fish" in the introduction for a description of the three categories and default assumptions about ESU membership). The third category consists of resident populations that are separated from anadromous conspecifics by recent human-made barriers such as dams without fish ladders. No default assumption about ESU membership was possible for Category 3 populations, so they are here considered case-by-case according to available information.

As of this writing there are few data on occurrence of resident populations and even fewer on genetic relationships. A provisional survey of the occurrence of Category 3 populations in the ESU (see Appendix B.5.2) revealed the following: In the watersheds inhabited by this ESU, 8% of stream kilometers lie behind two major recent barriers—Scott Dam on the Eel River and Robert Matthews dam on the Mad (Appendix B.5.2; major barriers are defined as blocking access to watersheds with areas of 100 sq. mi. or greater). Category 3 populations are documented to occur above both dams and there is ongoing stocking of hatchery fish in the Mad River above the dam. No such records of stocking were uncovered for the Eel above Scott Dam. There do not appear to be any relevant genetic studies of these Category 3 populations.

B.2.6.3 New Hatchery Information

California hatchery stocks being considered for inclusion in this ESU are those from Mad River Hatchery, Yager Creek Hatchery, and the North Fork Gualala River Steelhead Project. The stocks and their associated hatcheries were assigned to one of three categories for the purpose of determining ESU membership at some future date (See "Artificial Propagation" in the introduction for a description of the three categories and related issues regarding ESU membership). To make the assignments, data about broodstock origin, size, management, and genetics were gathered from fisheries biologists and are summarized below.

Mad River Hatchery (Mad River Steelhead [CDFG])

The Mad River Hatchery is located 20 km upriver near the town of Blue Lake (CDFG/NMFS 2001). The trap is located at the hatchery.

Broodstock origin and history—The hatchery was opened in 1970 and steelhead were first released in 1971. The original steelhead releases were from adults taken at Benbow Dam on the South Fork Eel River. Between 1972 and 1974, broodstock at Mad River Hatchery were composed almost exclusively of steelhead from the South Fork Eel River. After 1974, returns to the hatchery supplied about 90% of the egg take; other eggs originated from Eel River steelhead. In addition, at least 500 adult steelhead from the San Lorenzo River were spawned at Mad River Hatchery in 1972. Progeny of these fish may have been planted in the basin. All subsequent broodyears are reported to have come from trapping at the hatchery.

Broodstock size/natural population size—An average of 5,536 adults were trapped from 1991 to 2002 and an average of 178 females were spawned during the broodyears 1991-2002. There are no abundance estimates for the Mad River, but steelhead were observed to be widespread and abundant throughout the basin.

Management—Starting in 1998, steelhead are 100% marked and fish are included in the broodstock in proportion to the numbers returned. The current production goals are 250,000 yearlings raised to 4-8/lb for release in March to May.

Population genetics—Alloyzme data group Mad River samples in with the Mad River Hatchery and then with the Eel River (Busby et al.1996).

Category—The hatchery has been determined to belong in Category 3. There have been no introductions since 1974, and naturally spawned fish are being included in the broodstock. However, there is still an out-of-basin nature to the stock (SSHAG 2003; see Appendix B.5.3).

Yager Creek Hatchery (Yager Creek Steelhead [PalCo])

The Yager Creek trapping and rearing facility is located at the confluence of Yager and Cooper Mill creeks (tributaries of the Van Duzen River, which is a tributary of the Eel River).

Broodstock origin and history—The project was initiated in 1976. Adult broodstock are taken from Yeager Creek and juveniles are released in the Van Duzen River basin. As with all Co-operative hatcheries, the fish are all marked and hatchery fish are usually excluded from broodstock (unless wild fish are rare). There are no records of introductions to the broodstock.

Management—About 4,600 juvenile steelhead from Freshwater Creek (a tributary of Humboldt Bay) were released in the Yager Creek Basin in 1993 (Busby et al. 1996). The current program goal is the restoration of Van Duzen River Steelhead.

Population genetics—There are no genetic data for this hatchery.

Category—This hatchery was determined to belong to Category 1. The broodstock has had no out-of-basin introductions and hatchery fish are excluded from the broodstock (SSHAG 2003; see Appendix B.5.3).

North Fork Gualala River Hatchery (Gualala River Steelhead Project [CDFG/Gualala River Steelhead Project])

This project rears juvenile steelhead rescued from tributaries of the North Fork Gualala River. Rearing facilities are located on Doty Creek, a tributary of the Gualala River 12 miles from the mouth. Steelhead smolts resulting from this program are released in Doty Creek, the mainstem of the Gualala River, and other locations in the drainage.

Broodstock origin and history—The project was started in 1981 and has operated sporadically since then. Juvenile steelhead are rescued from the North Fork of the Gualala River and reared at Doty Creek.

Management—The current program goal is restoration of Gualala River steelhead.

Population genetics—There are no genetic data for this hatchery.

Category—Determined to be Category 1. Usually only naturally spawned juveniles are reared at the facility (SSHAG 2003; see Appendix B.5.3).

B.2.7 CENTRAL CALIFORNIA COAST STEELHEAD

Primary contributor: David Boughton

(Southwest Fisheries Science Center – Santa Cruz Lab)

B.2.7.1 Summary of Previous BRT Conclusions

The Central California Coast ESU was determined to inhabit coastal basins from the Russian River (Sonoma County), to Soquel Creek (Santa Cruz County) inclusive (Busby et al. 1996). Also included in this ESU are populations inhabiting tributaries of San Francisco and San Pablo bays (though there is some uncertainty about the latter). The ESU is composed only of winter-run fish.

Summary of major risks and status indicators

Risks and limiting factors—Two significant habitat blockages reported by Busby et al. (1996) are the Coyote and Warm Springs Dams in the Russian River watershed; data indicated that other smaller fish passage problems were widespread in the geographic range of the ESU. Other impacts noted in the status report were: urbanization and poor land-use practices; catastrophic flooding in 1964 causing habitat degradation; and dewatering due to irrigation and diversion. There has been no formal analysis of the relative strengths of these various impacts. Principal hatchery production in the region comes from the Warm Springs Hatchery on the Russian River, and the Monterey Bay Salmon and Trout Project on a tributary of Scott Creek. At the time of the status review there were other small private programs producing steelhead in the range of the ESU, reported by Bryant (1994) to be using stocks indigenous to the ESU, but not necessarily to the particular basin in which the program was located. There was no information on the actual contribution of hatchery fish to naturally spawning populations.

Status indicators—One estimate of historical (pre-1960s) abundance was reported by Busby et al. (1996): Shapovalov and Taft (1954) described an average of about 500 adults in Waddell Creek (Santa Cruz County) for the 1930s and early 1940s. A bit more recently, Johnson (1964) estimated a run size of 20,000 steelhead in the San Lorenzo River before 1965, and CDFG (1965) estimated an average run size of 94,000 steelhead for the entire ESU, for the period 1959-1963 (see Table B.2.7.5 for a breakdown of numbers by basin). The analysis by CDFG (1965) was compromised by the fact that for many basins, the data did not exist for the full 5-year period of their analysis. The authors of CDFG (1965) state that "estimates given here which are based on little or no data should be used only in outlining the major and critical factors of the resource."

Recent data for the Russian and San Lorenzo Rivers (CDFG 1994, Reavis 1991, Shuman 1994[12]; see Table B.2.7.5) suggested that these basins had populations smaller than 15% of the size that they had had 30 years previously. These two basins were thought to have originally contained the two largest steelhead populations in the ESU.

[12] The basis for the estimates provided by Shuman (1994) appears to be questionable.

A status review update conducted in 1997 (NMFS 1997) concluded that slight increases in abundance occurred in the 3 years following the status review, but the analyses on which these conclusions were based had various problems, including inability to distinguish hatchery and wild fish, unjustified expansion factors, and variance in sampling efficiency on the San Lorenzo River. Presence/absence data compiled by P. Adams (SWFSC, personal communication) indicated that most (82%) sampled streams (a subset of all historical steelhead streams) had extant populations of juvenile *O. mykiss*.

Table B.2.7.5. Summary of estimated runs sizes for the Central Coast steelhead ESU, reproduced from Busby et al. (1996), Tables 19 & 20.

River Basin	Estimate of Run Size	Year	Reference
Russian River	65,000	1970	CACSS (1988)
	1750 – 7000	1994	McEwan and Jackson (1996), CDFG (1994)
Lagunitas Creek	500		CDFG (1994)
	400 – 500	1990s	McEwan and Jackson (1996)
San Gregorio	1,000	1973	Coots (1973)
Waddell Creek	481	1933–1942	Shapovolov and Taft (1954)
	250	1982	Shuman (1994)[13]
	150	1994	Shuman (1994)[13]
Scott Creek	400	1991	Nelson (1994)
	<100	1991	Reavis (1991)
	300	1994	Titus et al. (MS)
San Vicente Creek	150	1982	Shuman (1994)[13]
	50	1994	Shuman (1994)[13]
San Lorenzo River	20,000	Pre-1965	Johnson (1964), SWRCB (1982)
	1,614	1977	CDFG (1982)
	>3,000	1978	Ricker and Butler (1979)
	600	1979	CDFG (1982)
	3,000	1982	Shuman (1994)[13]
	"few"	1991	Reavis (1991)
	<150	1994	Shuman (1994)[13]
Soquel Creek	500 – 800	1982	Shuman (1994)[13]
	<100	1991	Reavis (1991)
	50 – 100	1994	Shuman (1994)[13]
Aptos Creek	200	1982	Shuman (1994)[13]
	<100	1991	Reavis (1991)
	50 – 75	1994	Shuman (1994)[13]

[13] The basis for the estimates provided by Shuman (1994) appears to be questionable.

Previous BRT conclusions

The original BRT concluded that the ESU was in danger of extinction (Busby et al. 1996). Extirpation was considered especially likely in Santa Cruz County and in the tributaries of San Pablo and San Francisco Bays. The BRT suggested that abundance in the Russian River (the largest system inhabited by the ESU) has declined seven-fold since the mid-1960s, but abundance appeared to be stable in smaller systems. Two major sources of uncertainty were: 1) few data on run sizes, which necessitated that the listing be based on indirect evidence, such as habitat degradation; and 2) genetic heritage of populations in tributaries to San Francisco and San Pablo Bays was uncertain, causing the delineation of the geographic boundaries of the ESU to be uncertain. A status review update (NMFS 1997) concluded that conditions had improved slightly, and that the ESU was not presently in danger of extinction, but was likely to become so in the foreseeable future (Minorities supported both more and less extreme views on extinction risk). Uncertainties in the update mainly revolved around sampling efforts that were inadequate for detecting status or trends of populations inhabiting various basins.

Listing status

The status of steelhead was formally assessed in 1996 (Busby et al. 1996). The original status review was updated in 1997 (NMFS 1997), and the Central California Coast ESU was listed as threatened in August 1997.

B.2.7.2 New Data and Updated Analyses

There are two significant sets of new information regarding status: 1) numerous reach-scale estimates of juvenile abundance have been made for populations of the ESU, and 2) harvest regulations have been substantially changed since the last status review. Analyses of this information are described below.

Juvenile data

Data on juvenile abundance have been collected at a number of sites using a variety of methods (Alley and Assoc. 1994, 1995, 1997, 1998, 1999, 2000, 2002a, 2002b; Smith 1992, 1994a, 1994b, 1994c, 1995, 1996a, 1996b, 1996c, 1997, 1998a, 1998b, 1998c, 1999, 2000a, 2000b 2001a, 2001b, 2002). Many of the methods involve the selection of reaches thought to be "typical" or "representative" steelhead habitat. In general, the field crew made electro-fishing counts (usually multiple-pass, depletion estimates) of the young-of-the-year and 1+ age classes. Most of the target reaches got sampled several years in a row; thus there are a large number of short time-series. Although methods were always consistent within a time-series, they were not necessarily consistent across time-series.

Because there are so few adult data on which to base a risk assessment of this ESU, we chose to analyze these juvenile data. However, we note that they have limited usefulness for understanding the status of the adult population, due to non-random sampling of reaches within stream systems; non-random sampling of populations within the ESU; and a general lack of estimators shown to be robust for estimating fish density within a reach. In addition, even if more rigorous methods had been used, there is no simple relationship between juvenile numbers and adult numbers (Shea and Mangel 2001), the latter being the usual currency for status reviews. Table B.2.6.4 describes the various possible ways that one might translate juvenile trends into inferences about adult trends.

To estimate a trend in the juvenile data, the data within each time-series were log-transformed and then normalized, so that each datum represented a deviation from the mean of that specific time-series. The normalization is intended to prevent spurious trends that could arise from the diverse set of methods used to collect the data. Then, the time-series were grouped into units thought to plausibly represent independent populations; the grouping was based on watershed structure. Finally, within each population a linear regression was done for the mean deviation versus year. The estimator for time-trend within each grouping is the slope of the regression line. The minimum number of observations per time-series is 6 years (Other assessments in this status review place the cut-off at 10 years.). The general lack of data on this ESU prompted us to consider these data despite the brevity of some series.

This procedure resulted in five independent populations for which a trend was estimated (the five sites are the San Lorenzo River, Scott Cr., Waddell Cr., Gazos Cr., and Redwood Cr. [Marin Co.]). Only downward trends were observed in the five populations (Figure B.2.7.4). The mean trend across all populations was significantly less than zero (H_o: slope ≥ 0; $p < 0.022$ via one-tailed t-test against expected value). This suggests an overall decline in juvenile abundance, but it is important to note that such a conclusion requires the assumptions that the assessed populations 1) are indeed independent populations rather than plausibly independent populations, and 2) were randomly sampled from all populations in the ESU (they are probably better regarded as having been haphazardly sampled).

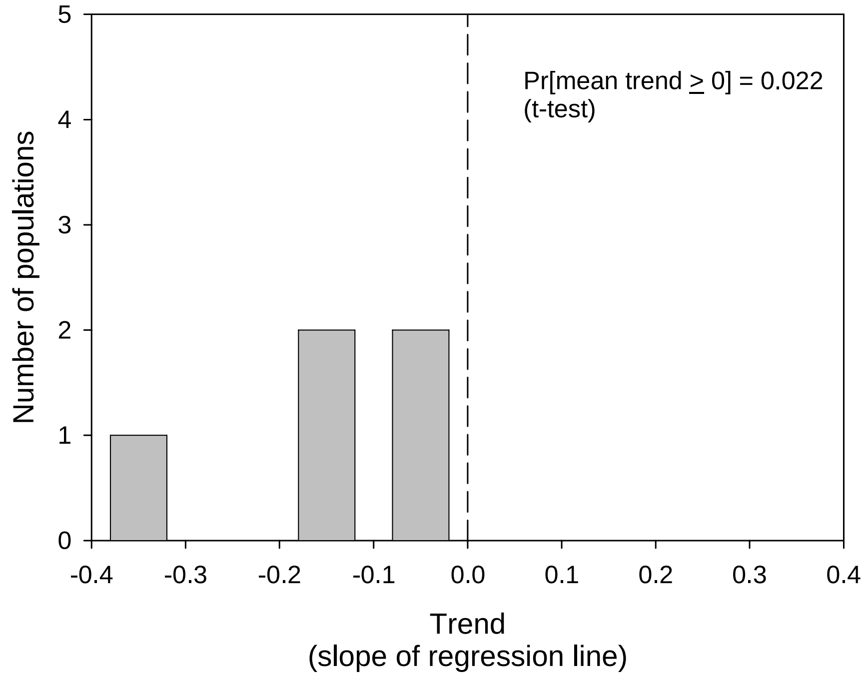


Figure B.2.7.4. Distribution of trends in juvenile densities, for five “independent” populations within the Central Coast steelhead ESU (see text for description of methods). Trend is measured as the slope of a regression line through a time-series; values less than zero indicate decline; values greater than zero indicate increase. Assuming that the populations were randomly drawn from the ESU as a whole, the hypothesis that the ESU is stable or increasing can be statistically rejected (*p* = 0.022); implying an overall decline.

Possible changes in harvest impacts

Since the original status review of Busby et al. (1996), regulations concerning sport fishing have been changed in a way that probably reduces extinction risk for the ESU.

Sport harvest in the ocean is prohibited by the California Department of Fish and Game (CDFG 2002a), and ocean harvest is a rare event (M. Mohr, NMFS, pers. comm.). For freshwaters (CDFG 2002b), all coastal streams are closed to fishing year round except for special listed streams that allow catch-and-release angling or summer trout fishing. Catch-and-release angling with restricted timing (generally, winter season Sundays, Saturdays, Wednesdays, and holidays) is allowed in the lower main stems of many coastal streams south of San Francisco (Aptos Creek, Butano Creek, Pescadero Creek, San Gregorio Creek, San Lorenzo River, Scott Creek, Soquel Creek). Notably, Waddell Creek in Santa Cruz Co. for awhile had a 5-per day bag limit during the winter, for the short reach between Highway 1 and the ocean; this was a mistake as the bag limit was reduced to zero in the supplementary regulations issued in a separate document (CDFG 2002c). Catch and release is allowed year round except April and May in the lower parts of Salmon Creek in Sonoma County and Walker Creek in Marin County. Russian Gulch in Sonoma County has similar regulations except that 1 hatchery fish may be taken in the winter.

The Russian River is the largest system and probably originally supported the largest steelhead population in the ESU. The mainstem is currently open all year and has a bag limit of 2 hatchery steelhead or trout. Above the confluence with the East Branch it is closed year round. Santa Rosa Creek and Laguna Santa Rosa, Sonoma County tributaries to the Russian River, have a summer catch-and-release fishery.

Tributaries to the San Francisco Bay system have less restricted fisheries. All streams in Alameda, Contra Costa, and Santa Clara Counties (east and south Bay) have summer fisheries with bag limit five, except for special cases that are closed all year (Mitchell Creek, Redwood Creek in Alameda Co., San Francisquto Creek and tributaries, and Wildcat Creek). In the north Bay, the lower mainstem of the Napa River has catch-and-release year round except April and May; there is a bag limit of 1 hatchery steelhead or trout. Upper Sonoma Creek and tributaries have a summer fishery with bag limit 5. Summer trout fishing is allowed in some lakes and reservoirs or in tributaries to lakes, generally with 2 or 5 bag limit.

For catch-and-release streams, all wild steelhead must be released unharmed. There are significant restrictions on gear used for angling. The CDFG has prepared a draft Fishery Management and Evaluation Plan (CDFG 2001a) that argues the upper limit of increased mortality due to sport fishing to be about 2.5% in all populations. This estimate is based on an estimated mortality rate of 5% once a fish is hooked, which is consistent with a published meta-analysis of hooking mortality (Schill and Scarpella 1997). Experimental studies on the subject—from which the estimates are made—tend to measure mortality only for a period of a few days or a week after capture (e.g. Titus and Vanicek 1988).

The Fishery Management and Evaluation Plan contains no extensive plans for monitoring fish abundance. Although the closure of many areas, and institution of catch-and-release elsewhere, is expected to reduce extinction risk for the ESU, this risk reduction cannot be estimated quantitatively from the existing datasets, due to the fact that natural abundance is not being measured.

Resident *O. mykiss* considerations

Resident (non-anadromous) populations of *O. mykiss* were assigned to one of three categories for the purpose of provisionally determining ESU membership (See "Resident Fish" in the introduction for a description of the three categories and default assumptions about ESU membership). The third category consists of resident populations that are separated from anadromous conspecifics by recent human-made barriers such as dams without fish ladders. No default assumption about ESU membership was possible for Category 3 populations, so they are considered case-by-case according to available information.

As of this writing there are few data on occurrence of resident populations and even fewer on genetic relationships. A provisional survey of the occurrence of Category 3 populations in the ESU (see Appendix B.5.2) revealed the following: In the watersheds inhabited by this ESU, at least 26% of stream kilometers lie behind recent barriers, and a number of resident populations are known to occur above the barriers (Appendix B.5.2). One significant set of Category 3 populations is in Alameda Creek, a tributary of San Francisco Bay. Nielson (2003) examined mitochondrial DNA and microsatellite DNA of fish from four subbasins of Alameda Creek and found that three of the subpopulations were most similar to each other and were more similar to populations from other creeks within the ESU (Lagunitas and San Francisquito creeks) than they were to populations outside the ESU. This strongly suggests that these Category 3 subpopulations should be considered part of the ESU. The fourth subpopulation, which occurred in Arroyo Mocho, was quite distinct and was more similar to Whitney hatchery stocks than it was to other subpopulations within the basin or even the wider ESU. Nielson (2003) suggests that this population may either be a population of native rainbow trout with no association to anadromous forms, or has experienced significant genetic introgression from introduced hatchery stocks.

Gall et al. (1990) examined the genetics of two populations in tributaries of the Upper San Leandro Reservoir, on San Leandro Creek. This creek drains into the San Francisco Bay and is, interestingly, the type locality for *Salmo irideus*, now known as *Oncorhynchus mykiss irideus* (Gall et al. 1990, Behnke 1992). Gall et al. (1990) analyzed genetic variability at 17 marker loci using electrophoresis, and concluded that the populations truly belonged to the coastal subspecies of *O. mykiss* (i.e. ssp. *irideus*). However, their study was not designed to assess whether the populations were more similar to hatchery stocks than to nearby wild populations. They reported anecdotal observations that the fish make steelhead-like runs to and from the reservoir.

B.2.7.3 New Hatchery Information

California hatchery stocks being considered for inclusion in this ESU are those from Don Clausen Fish Hatchery and the Monterey Bay Salmon & Trout Project. The stocks and their associated hatcheries were assigned to one of three categories for the purpose of determining ESU membership at some future date (See "Artificial Propagation" in the introduction for a description of the three categories and related issues regarding ESU membership). To make the assignments, data about broodstock origin, size, management, and genetics were gathered from fisheries biologists and are summarized below.

Don Clausen Fish Hatchery (Warm Springs steelhead [CDFG])

The hatchery and collection site is located on Dry Creek, 14 miles above the confluence of Dry Creek and the Russian River and 47 river miles from the ocean. In 1992, the Coyote Valley Fish Facility was opened at the base of Coyote Valley Dam on the East Fork of the Russian River, 98 miles from the ocean. Both facilities trap fish on site. Coyote Valley fish are trapped and spawned there, but raised at Don Clausen Hatchery. The Coyote Valley steelhead are imprinted for 30 days at the facility before release.

Broodstock origin and history—The hatchery was founded in 1981 and the first steelhead releases were in 1982. The Coyote Valley Fish Facility was opened in 1992. Don Clausen Hatchery has had few out-of-basin transfers into its broodstock. However, significant numbers of Mad River Hatchery steelhead have been released into the basin. In the earlier part of the century, steelhead from Scott Creek were released throughout the basin. Since the Coyote Valley Fish Facility has been constructed, broodstock has been trapped at the facility.

Broodstock size/natural population size—At Don Clausen Hatchery, an average of 3,301 fish were trapped and 244 females were spawned during the broodyears 1992-2002. At the Coyote Valley Fish Facility, there have been an average of 1,947 steelhead trapped from 1993-2002 and an average of 124 females spawned. There are no steelhead abundance estimates for the Russian River, but fish are observed to be widely distributed and plentiful (NMFS, draft HGMP).

Management—As of 1998, steelhead have been 100% ad-clipped. Until broodyear 2000, both hatchery and naturally spawned fish had been included in the broodstock in the proportion that they returned to the hatchery. Since then, only adipose-marked fish are spawned and all unmarked steelhead are relocated into tributaries of Dry Creek. The production goal for Don Clausen Hatchery is 300,000 yearlings released beginning in December by size, with all fish released by April. The Coyote Valley Facility’s goal is 200,000 yearlings that volitionally release between January and March.

Category—The hatchery has been determined to belong to Category 2 (SSHAG 2003; Appendix B.5.3). Although some out-of-ESU stocks were present in the basin, there have been no significant introductions since the hatchery began operations. The stock itself has only been cultivated for 20 years. The run is abundant and naturally spawned fish were included in the broodstock until 2000. Since that time only adipose-marked steelhead have been spawned.

Monterey Bay Salmon & Trout Project (Kingfisher Flat [Big Creek] Hatchery; Scott Creek steelhead)

The Kingfisher Flat Hatchery is located on Big Creek, a tributary of Scott Creek 6 km upstream from the mouth. Broodstock are taken by divers netting adults, usually in Big Creek below the hatchery, but at times throughout the Scott Creek system (NMFS, draft Biological Opinion). Steelhead are also taken at a trap on the San Lorenzo River in Felton. San Lorenzo River steelhead are kept separately and released back into the San Lorenzo Basin.

Broodstock origin and history—The Kingfisher Flat Hatchery began in 1975. However, California state hatchery activity near this site has a long history back to 1904 (Strieg 1991). The state hatchery program ended in 1942 due to flood damage. Under the California state hatchery program, Scott Creek steelhead were widely planted throughout coastal California as they were thought to be an exceptionally healthy stock. The hatchery was damaged by floods in 1941-42 and closed. There are limited records of introductions from Mt. Shasta and Prairie Creek hatcheries into this broodstock.

In 1976, the Monterey Bay Salmon & Trout Project began operations at the Big Creek location. Since then, broodstock have been taken either in Scott Creek by divers or at a trap in the San Lorenzo River near Felton. Since that time, there have been no introductions into the broodstock. As with all Co-operative hatcheries, the fish are all marked and hatchery fish are usually excluded from broodstock. Fish are released in either Scott Creek or the San Lorenzo River depending on the source of the broodstock.

Broodstock size/natural population size—An average of 98 fish were trapped and 25 females spawned during the 1990-96 broodyears. There are no abundance estimates for Scott Creek and the San Lorenzo River, but juveniles have been observed anecdotally to be widespread and abundant (NMFS, draft Biological Opinion).

Management—Starting in 2000, the practice of planting San Lorenzo fish into the North Fork of the Pajaro River Basin was discontinued. Although the distance is only a matter of miles, it is across ESU boundaries. The current program goal is the restoration of local steelhead stocks.

Population genetics—Alloyzme data groups the Scott Creek, San Lorenzo and Carmel River stocks together (Busby et al. 1996). Collectively they fall within the "south-of-the-Russian-River" grouping.

Category—The hatchery was determined to fall into Category 1 (SSHAG 2003; Appendix B.5.3). The stock has not had out-of-basin introductions in recent years, and hatchery fish are excluded from the broodstock.

B.2.8 SOUTH-CENTRAL CALIFORNIA STEELHEAD

Primary contributor: David Boughton

(Southwest Fisheries Science Center – Santa Cruz Lab)

B.2.8.1 Summary of Previous BRT Conclusions

The geographic range of the ESU was determined to extend from the Pajaro River basin in Monterey Bay south to, but not including, the Santa Maria River Basin near the town of Santa Maria. The ESU was separated from steelhead populations to the north on the basis of genetic data (mitochondrial DNA and allozymes), and from steelhead populations to the south on the basis of a general faunal transition in the vicinity of Point Conception. The genetic differentiation of steelhead populations within the same ESU, and the genetic differentiation between ESUs, appears to be greater in the south than in Northern California or the Pacific Northwest; however the conclusion is based on genetic data from a small number of populations.

Summary of major risks and status indicators

Risks and limiting factors—Numerous minor habitat blockages were considered likely throughout the region; other typical problems were thought to be dewatering from irrigation and urban water diversions, and habitat degradation in the form of logging on steep erosive slopes, agricultural and urban development on floodplains and riparian areas, and artificial breaching of estuaries during periods when they are normally closed off from the ocean by a sandbar.

Status indicators—Historical data on this ESU are sparse. In the mid 1960s, the CDFG (1965) estimated that the ESU-wide run size was about 17,750 adults. No comparable recent estimate exists; however, recent estimates exist for five river systems (Pajaro, Salinas, Carmel, Little Sur, and Big Sur), indicating runs of fewer than 500 adults where previously runs had been on the order of 4,750 adults (CDFG 1965). Time-series data only existed for one basin (the Carmel River), and indicated a decline of 22% per year over the interval 1963 to 1993 (see below for a review of this conclusion).

Many of the streams were thought to have somewhat to highly impassable barriers, both natural and anthropogenic, and in their upper reaches to harbor populations of resident trout. The relationship between anadromous and resident *O. mykiss* is poorly understood in this ESU, but was thought to play an important role in its population dynamics and evolutionary potential. A status review update conducted in 1997 (NMFS 1997) listed numerous reports of juvenile *O. mykiss* in many coastal basins; but noted that the implications for adult numbers were unclear. They also discussed the fact that certain inland basins (the Salinas and Pajaro systems) are rather different ecologically from coastal basins.

Previous BRT Conclusions

The original BRT (Busby et al. 1996) concluded that the ESU was in danger of extinction, due to 1) low total abundance; and 2) downward trends in abundance in those stocks for which data existed. The negative effects of poor land-use practices and trout stocking were also noted. The major area of uncertainty was the lack of data on steelhead run sizes, past and present. The status review update (NMFS 1997) concluded that abundance had slightly increased in the years immediately preceding, but that overall abundance was still low relative to historical numbers. They also expressed a concern that high juvenile abundance and low adult abundance observed in some datasets suggested that many or most juveniles were potentially resident fish (i.e. rainbow trout). The BRT convened for the update was nearly split on whether the fish were in danger of extinction, or currently not endangered but likely to become so in the foreseeable future, with the latter view holding a slight majority.

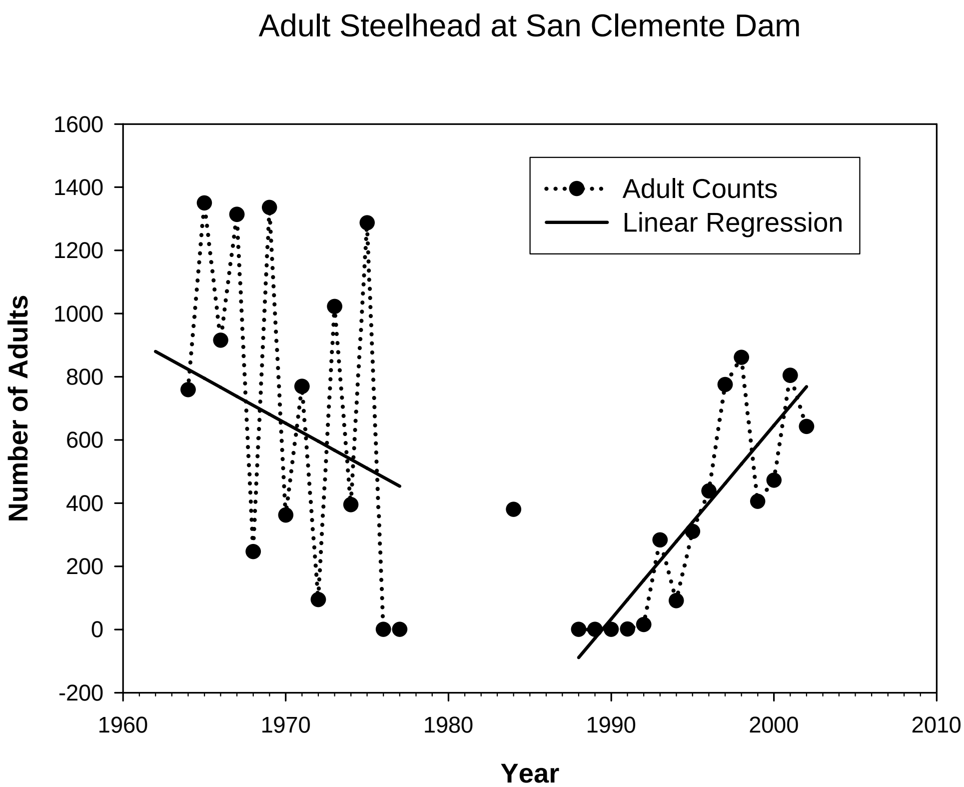


Figure B.2.8.1. Adult counts at San Clemente Dam, Carmel River. Data from the Monterey Peninsula Water Management District. See Snider (1983) for methods of counting fish before 1980; these early data are subject to substantial observation error (*N.B.* the regression line is not significantly different from flat). The increase during the 1990s followed a severe drought (and concurrent dewatering of the mainstem by a water district) in the late 1980s and early '90s.

Listing Status

The ESU was listed as threatened in 1997.

B.2.8.2 New Data and Updated Analyses

There are three new significant pieces of information: 1) updated time-series data concerning dam counts made on the Carmel River (MPWMD 2002) (See analyses section below for further discussion); 2) a comprehensive assessment of the current geographic distribution of *O. mykiss* within the ESU's historical range (Boughton & Fish MS; see next paragraph); and (3) changes in harvest regulations since the last status review (see next section).

Table B.2.8.1. Estimates of historical run sizes from the previous status review (Busby 1996).

River Basin	Run size estimate	Year	Reference
Pajaro R.	1,500	1964	McEwan and Jackson 1996
	1,000	1965	McEwan and Jackson 1996
	2,000	1966	McEwan and Jackson 1996
Carmel R.	20,000	1928	CACSS (1988)
	3,177	1964 – 1975	Snider (1983)
	2,000	1988	CACSS (1988)
	<4,000	1988	Meyer Resources (1988)

Current distribution vs. historical distribution—In 2002, an extensive study was made of steelhead occurrence in most of the coastal drainages between the northern and southern geographic boundaries of the ESU (Boughton and Fish MS). Steelhead were considered to be present in a basin if adult or juvenile *O. mykiss* were observed in any stream reach that had access to the ocean (i.e. no impassable barriers between the ocean and the survey site), in any of the years 2000-2002 (i.e. within one steelhead generation). Of 36 drainages in which steelhead were known to have occurred historically, between 86% and 94% were currently occupied by *O. mykiss*. The range in the estimate of occupancy occurs because three basins could not be assessed due to restricted access. Of the vacant basins, two were considered to be vacant because they were dry in 2002, and one was found to be watered but a snorkel survey revealed no *O. mykiss*. One of the "dry" basins—Old Creek—is dry because no releases were made from Whale Rock Reservoir; however, a land-locked population of steelhead is known to occur in the reservoir above the dam.

Occupancy was also determined for 18 basins with no historical record of steelhead occurrence. Three of these basins—Los Osos, Vicente, and Villa Creeks—were found to be occupied by *O. mykiss*. It is somewhat surprising that no previous record of steelhead seems to exist for Los Osos Creek, near Morro Bay and San Luis Obispo.

The distribution of steelhead among the basins of the region is not much less than what occurred historically, so despite the widespread declines in habitat quality and population sizes, regional extirpations have not yet occurred. This conclusion rests on the assumption that juveniles inhabiting stream reaches with access to the ocean will undergo smoltification and thus are truly steelhead.

Three analyses are made below: 1) A critical review of the historical run sizes cited in the previous status review, 2) an assessment of recent trends observed in the adult counts being made on the Carmel River; and 3) a summary of new sport-fishing regulations in the region.

Review of historical run sizes—Estimates of historical sizes for a few runs were described in the previous status review (Busby et al. 1996), and are here reproduced in Table B.2.8.1.

The recent estimates for the Pajaro River (1,500, 1,000, 2,000) were reported in McEwan and Jackson (1996), but the methodology and dataset used to produce the estimates were not described. CACCS (1988) suggested an annual run size of 20,000 adults in the Carmel River of the 1920s, but gave no supporting evidence for the estimate. Their 1988 estimate of 2,000 adults also lacked supporting evidence. Meyer Resources (1988) provides an estimate of run size, but was not available for review at the time of this writing.

Snider (1983) examined the Carmel River and produced many useful data. In the abstract of his report he gave an estimate of 3,177 fish as the mean annual smolt production for 1964 through 1975; Busby et al. (1996) mistakenly cited this estimate as an estimate of run size. Snider's "3,177" figure may itself be a mistake, as it disagrees with the information in the body of the report, which estimates annual smolt production in the year 1973 as 2,708 smolts, and in the year 1974 as 2,043 smolts. Snider (1983) also gives adult counts for fish migrating upstream through the fish ladder at San Clemente Dam, for the years 1964 through 1975 (data were not reported in Busby et al. 1996; but were apparently the basis for the 22% decline reported by them. See Figure B.2.8.1 for the actual counts.). The mean run size from these data is 821 adults. To make these estimates, visual counts were made twice a day by reducing the flow through the ladder and counting the fish in each step; thus they may underestimate the run size by some unknown amount if fish moved completely through the ladder between counts (an electronic counter was used in 1974 and 1975 and presumably is more accurate). In addition, San Clemente Dam occurs 19.2 miles from the mouth of the river and a fraction of the run spawns below the dam (CDFG biologists estimate the fraction to be one third of the run, based on redd surveys).

Thus, much of the historical data used in the previous status review are highly uncertain. The most reliable data are the Carmel River dam counts, which were not reported in the previous status review. Further analysis of these data are described below.

Abundance in the Carmel River—The Carmel River data are the only time-series for the ESU. The data suggest that the abundance of adult spawners in the Carmel River has increased since the last status review (Figure B.2.8.1.). A continuous series of data exists for 1964 through 1977, although the data are probably incomplete to various degrees for each year (i.e. the counts are probably incomplete, and the year-to-year fluctuations may be mostly due to observation error rather than population variability). A regression line drawn through the data indicates a downward trend, but the trend is not statistically significant (slope = -28.45; R^2 = 0.075; F = 1.137; p = 0.304;). The 22% decline reported by Busby et al. (1996) is apparently based on these data in comparison with the low numbers of the early 1990s.

Continuous data have also been collected for the period 1988 through 2002. The beginning of this time series has counts of zero adults for three consecutive years, then shows a rapid increase in abundance. The trend is strongly upward (see Table B.2.6.3). The time series is too short to make a reliable estimate of mean lambda. The observed positive trend could conceivably be due either to improved conditions (i.e. mean lambda greater than one), substantial immigration or transplantation, or the transient effects of age structure. Improved conditions seem by far the most likely explanation, as the basin has been the subject of intensive fisheries management since the early 1990s. According to the Monterey Peninsula Water Management

District, the entity conducting much of the restoration of the basin's steelhead fishery, the likely reasons for the positive trend are due to improved conditions, namely

> "Improvements in streamflow patterns, due to favorable natural fluctuations…since 1995; …actively manag[ing] the rate and distribution of groundwater extractions and direct surface diversions within the basin; changes to Cal-Am's [dam] operations … providing increased streamflow below San Clemente Dam; improved conditions for fish passage at Los Padres and San Clemente Dams …; recovery of riparian habitats, tree cover along the stream, and increases in woody debris…; extensive rescues … of juvenile steelhead over the last ten years … ; transplantation of the younger juveniles to viable habitat upstream and of older smolts to the lagoon or ocean; and implementation of a captive broodstock program by Carmel River Steelhead Association and California Department of Fish & Game (CDFG), [including] planting … from 1991 to1994." (MPWMD 2001).

Even so, the rapid increase in adult abundance from 1991 (one adult) to 1997 (775 adults) seems too great to attribute simply to improved reproduction and survival of the local steelhead. There are a number of possibilities: substantial immigration or transplantation may have boosted abundance, or perhaps there was a large population of resident trout that has begun producing smolts at a higher rate under improved freshwater conditions. The transplantation hypothesis is thought unlikely: although transplantation of juveniles occurred (in the form of rescues from the lower mainstem during periods in which it was dewatered), CDFG biologists consider the scale of these efforts to be too small to effect the large increase in run size that has been observed. The scale of immigration (i.e. straying) is not known but may be a significant factor. As for the role of resident trout in producing smolts, the phenomenon is known to occur but the environmental triggers have not yet been worked out. One hypothesis, congruent with the Carmel River situation, is that environmental conditions affect growth rate of juveniles, which affects propensity to smolt into the anadromous form.

The rapid increase in adult abundance in the Carmel River system is thus very interesting. At this point two conclusions seem warranted: 1) Upon improvement of freshwater conditions such as those described above, the adult runs are capable of rapid increase in this ESU, due either to resilience of steelhead populations, high stray rates, or ability of resident trout to produce smolts. Either mechanism might allow the fish to rapidly take advantage of improved conditions, suggesting a high potential for rapid recovery in this ESU if the proper actions were taken. 2) Although some component of the increase is probably due to improved ocean conditions, it would be a mistake to assume comparable increases have occurred in other basins of the ESU, as they have not been the focus of such intensive management efforts.

Possible changes in harvest impacts

Since the original status review of Busby et al. (1996), regulations concerning sport fishing have been changed in a way that probably reduces extinction risk for the ESU.

Sport harvest of steelhead in the ocean is prohibited by the California Department of Fish and Game (CDFG 2002a), and ocean harvest is a rare event (M. Mohr, NMFS, pers. comm.), so effects on extinction risk are probably negligible. For freshwaters, CDFG (2002) describes the current regulations. Summer trout fishing is allowed in some systems, often with a two- or five-bag limit. These include significant parts of the Salinas system (upper Arroyo Seco and Nacimiento above barriers; the upper Salinas; Salmon Creek; and the San Benito River in the Pajaro system (All: bag limit five trout). Also included in the summer fisheries is the Carmel River above Los Padres Dam (bag limit two trout, between 10" and 16"). A few other creeks have summer catch-and-release regulations. The original draft of the Fishery Management and Evaluation Plan (CDFG 2000) recommended complete closure of the Salinas system to protect the steelhead there, but the final regulations did not implement this recommendation, allowing both summer trout angling and winter-run catch-and-release steelhead angling in selected parts of the system (CDFG 2002).

The regulations allow catch-and-release winter-run steelhead angling in many of the river basins occupied by the ESU, specifying that all wild steelhead must be released unharmed. There are significant restrictions on timing, location, and gear used for angling. A recent draft Fisheries Evaluation and Management Plan (CDFG 2001b) has been prepared, and argues that the only mortality expected from a no-harvest fishery is from hooking and handling injury or stress. They estimate this mortality rate to be about 0.25% - 1.4%. This estimate is based on angler capture rates measured in other river systems throughout California (range: 5% - 28%), multiplied by an estimated mortality rate of 5% once a fish is hooked. The latter mortality estimate is consistent with a published meta-analysis of hooking mortality (Schill and Scarpella 1997), but experimental studies on the subject—from which the estimates are made—tend to measure mortality only for a period of a few days or a week after capture (e.g. Titus and Vanicek 1988).

The Fishery Management and Evaluation Plan contains no extensive plans for monitoring fish abundance. Although the closure of many areas, and institution of catch-and-release elsewhere, is expected to reduce extinction risk for the ESU, this risk reduction cannot be estimated quantitatively from the existing data, due to the fact that natural abundance is not being measured.

Resident *O. mykiss* considerations

Resident (non-anadromous) populations of *O. mykiss* were assigned to one of three categories for the purpose of provisionally determining ESU membership (See "Resident Fish" in the introduction for a description of the three categories and default assumptions about ESU membership). The third category consists of resident populations that are separated from anadromous conspecifics by recent human-made barriers such as dams without fish ladders. No default assumption about ESU membership was possible for Category 3 populations, so they are here considered case-by-case according to available information.

As of this writing there are few data on occurrence of resident populations and even fewer on genetic relationships. A provisional survey of the occurrence of Category 3 populations in the ESU (see Appendix B.5.2) revealed the following: There are four significant Category 3 populations within the original geographic range of the ESU (Appendix B.5.2)—two in the Salinas system, one behind Whale Rock Dam near Cayucos, and one behind the Lopez reservoir on Arroyo Grande Creek. The two in the Salinas system occur behind the dams on the Nacimiento and San Antonio Rivers, which currently block what were reported to be two of the three principal steelhead spawning areas in the basin (the other being in Arroyo Seco; Titus et al.

2003). Resident populations occur above these dams and stocking is ongoing (Appendix B.5.2). A third major barrier occurs in the headwaters of the Salinas itself; stocking currently occurs above this dam. Steelhead reportedly spawned in these streams before the dam was built, but the runs were probably relatively small and sporadic.

The Whale Rock Reservoir has a resident population that is reported to make steelhead-like runs up several tributaries for spawning. The reservoir has an associated hatchery program; see the previous section above for details on genetic studies, stocking records, *etc*.

According to David Starr Jordan, the area now blocked by the Lopez dam on Arroyo Grande Creek was originally well known as a significant steelhead area (cited in Titus et al. 2003). A resident population currently exists above this dam, and stocking is ongoing (Table B.5.1.1). We are not aware of any studies of the population's genetic affinities.

Minor barriers—defined here as blocking less than 100 sq. mi. of watershed—are numerous within the geographic range of the ESU. A nonzero number of Category 3 populations undoubtedly exist above these barriers but there are insufficient data at the present time to make a comprehensive assessment.

B.2.8.3. New Hatchery Information

The only hatchery stock being considered in this ESU is the one at Whale Rock Hatchery. This stock was assigned to one of three categories for the purpose of determining ESU membership at some future date (See "Artificial Propagation" in the introduction for a description of the three categories and related issues regarding ESU membership). To make the assignment, data about broodstock origin, size, management and genetics were gathered from fisheries biologists and are summarized below.

Whale Rock Hatchery (Whale Rock Steelhead [CDFG])

Whale Rock Reservoir was created in 1961 by placing a dam on Old Creek, 2 km upstream from the coast. Old Creek had supported a large steelhead run previous to construction of the dam and these fish were presumably trapped behind the dam (the creek is usually dewatered below the dam so no population occurs there at all). Whale Rock Hatchery was established in 1992 as an effort to improve the sport fishery in the reservoir after anglers reported a decline in fishing success. The original Whale Rock broodstock (40 fish) were collected at a temporary weir placed in the reservoir at the mouth of Old Creek Cove (Nielsen et al. 1997). Adult fish were trapped in the shallows of the reservoir using nets that are set during late winter and spring as the fish begin their migration upstream from the reservoir into Old Creek. The fish are held in an enclosure while they are monitored for ripeness. Eggs and sperm are collected from fish using non-lethal techniques, and then the adult fish are returned to the reservoir. Fish were originally hatched and raised at the Whale Rock Hatchery located below the dam at the maintenance facility, but are now raised at the Fillmore Hatchery in Ventura County. The fry are cared for until September or November at which time they are released back into the reservoir as 3-5" fingerling trout.

Broodstock origin and history—Hatchery operations began in 1992 and have been sporadic since. The project is a cooperative venture between CDFG and private parties. Fish were raised in 1992, 1994, 2000, and 2002 (John Bell, personal communication). All broodstock are taken from the reservoir.

Broodstock size/natural population size—An average of 121 fish were spawned. Spawning success has been poor. There are no population estimates for the reservoir and the hatchery fish are not marked.

Management—The current program goal is to increase angling success in Whale Rock Reservoir.

Population genetics—Neilsen et al. (1997) found that significant genetic relatedness occurs between the Whale Rock Hatchery stock and wild steelhead in the Santa Ynez River and Malibu creeks, two basins to the south. She reported a loss of genetic diversity within the hatchery stock.

Category—The hatchery was determined to belong to Category 2 (SSHAG 2003; Appendix B.5.3). Broodstock are taken from the source population, but the small population could easily lead to significant genetic bottlenecks.

B.2.9 SOUTHERN CALIFORNIA STEELHEAD

Primary contributor: David Boughton

(Southwest Fisheries Science Center – Santa Cruz Lab)

B.2.9.1 Summary of Previous BRT Conclusions

The geographic range of the ESU was determined to extend from the Santa Maria River basin near the town of Santa Maria, south to the United States border with Mexico. There is a report of *O. mykiss* populations in Baja California del Norte (Ruiz-Campos and Pister 1995); these populations are thought to be resident trout, but could be found to have an anadromous component with further study (note that they do not lie within the jurisdiction of the Endangered Species Act). NMFS (1997) cites reports of several other steelhead populations south of the border. The southern California ESU is the extreme southern limit of the anadromous form of *O. mykiss*. It was separated from steelhead populations to the north on the basis of a general faunal transition (in the fauna of both freshwater and marine systems) in the vicinity of Point Conception. The genetic differentiation of steelhead populations within the ESU, and from other ESUs in northern California or the Pacific Northwest appears to be great; however the conclusion is based on genetic data from a small number of populations.

Summary of major risks and status indicators

Risks and limiting factors—The original BRT noted that there has been extensive loss of populations, especially south of Malibu Creek, due to urbanization, dewatering, channelization of creeks, human-made barriers to migration, and the introduction of exotic fish and riparian plants. Many of these southern-most populations may have originally been marginal or intermittent (i.e. exhibiting repeated local extinctions and recolonizations in bad and good years respectively). No hatchery production exists for the ESU. The relationship between anadromous and resident *O. mykiss* is poorly understood in this region, but likely plays an important role in population dynamics and evolutionary potential of the fish.

Status indicators—Historical data on the ESU were sparse. The historical run size for the ESU was roughly estimated to be at least 32,000-46,000 (estimates for the four systems comprising the Santa Ynez, Ventura, Santa Clara Rivers, and Malibu Creek; this omits the Santa Maria system and points south of Malibu Creek). Recent run sizes for the same four systems were roughly estimated to be less than 500 adults total. No time series data were found for any populations.

Previous BRT conclusions

The original BRT concluded that that ESU was in danger of extinction, noting that populations were extirpated from much of their historical range (Busby et al. 1996). There was strong concern about widespread degradation, destruction, and blockage of freshwater habitats, and concern about stocking of rainbow trout. The two major areas of uncertainty were 1) lack of data on run sizes, past and present; and 2) the relationship between resident and anadromous forms of the species in the region. A second BRT convened for an update (NMFS 1997) found that the small amount of new data did not suggest that the situation had improved, and the majority view was that the ESU was still in danger of extinction.

Listing status

The ESU was listed as endangered in 1997. The original listing defined the ESU as having its southern geographic limits in Malibu Creek. Two small populations were subsequently discovered south of this point, and in 2002 a notice was published in the Federal Register, extending the range to include all steelhead found in drainages southward to the US border with Mexico.

B.2.9.2 New Data and Updated Analyses

There are four new significant pieces of information: 1) Four years of adult counts in the Santa Clara River; 2) observed recolonizations of vacant watersheds, notably Topanga Creek in Los Angeles county, and San Mateo Creek in Orange county; 3) a comprehensive assessment of the current distribution of *O. mykiss* within the historical range of the ESU (Boughton and Fish MS); and 4) changes in the harvest regulations of the sport fishery. Items (1), (2) and (4) are described further in the analyses section below; item (3) is described here:

Current distribution vs. historical distribution

In 2002, an extensive study was made of steelhead occurrence in most of the coastal drainages within the geographic boundaries of the ESU (Boughton and Fish MS). Steelhead were considered to be present in a basin if adult or juvenile *O. mykiss* were observed in any stream reach that had access to the ocean (i.e. no impassable barriers between the ocean and the survey site), in any of the years 2000-2002 (i.e. within one steelhead generation). Of 46 drainages in which steelhead were known to have occurred historically, between 37% and 43% were still occupied by *O. mykiss*. The range in the estimate of occupancy occurs because a number of basins could not be surveyed due to logistical problems, pollution, or lack of permission to survey on private land. Three basins were considered vacant because they were dry, 17 were considered vacant due to impassable barriers below all spawning habitat; and six were considered vacant because a snorkel survey found no evidence of *O. mykiss*. These snorkel surveys consisted of spot checks in likely-looking habitat and did not involve a comprehensive assessment of each basin.

One of the “dry” basins—San Diego River—may have water in some tributaries—it was difficult to establish that the entire basin below the dam was completely dry. Numerous anecdotal accounts suggest that several of the basins that had complete barriers to anadromy may have landlocked populations of native steelhead/rainbow trout in the upper tributaries. These basins include the San Diego, Otay, San Gabriel, Santa Ana, and San Luis Rey Rivers. Occupancy was also determined for 17 basins with no historical record of steelhead occurrence; none were found to be currently occupied.

Nehlsen et al. (1991) listed the following Southern California stocks as extinct: Gaviota Creek, Rincon Creek, Los Angeles River, San Gabriel River, Santa Ana River, San Diego River, San Luis Rey River, San Mateo Creek, Santa Margarita River, Sweetwater River, and Maria Ygnacio River. The distributional study of 2002 determined that steelhead were present in two of these systems, namely Gaviota Creek (Stoecker and CCP 2002) and San Mateo Creek (a recent colonization; see below). Nevertheless, the current distribution of steelhead among the basins of the region appears to be substantially less than what occurred historically. Except for the small population in San Mateo Creek in northern San Diego County, the anadromous form of the species appears to be completely extirpated from all systems between the Santa Monica Mountains and the Mexican border. Additional years of observations, either of presence or absence, would reduce the uncertainty of this conclusion.

Table B.2.9.1. Estimates from Busby et al. (1996), for run sizes in the major river systems of the southern steelhead ESU.

River basin	Run size estimate	Year	Reference
Santa Ynez	20,000 – 30,000	Historic	Reavis (1991)
	12,995 – 25,032	1940s	Shapovalov & Taft (1954)
	20,000	Historic	Titus et al (MS)
	20,000	1952	CDFG (1982)
Ventura	4,000-6,000	Historic	AFS (1991)
	4,000-6,000	Historic	Hunt et al. (1992)
	4,000-6,000	Historic	Henke (1994)
	4,000-6,000	Historic	Titus et al. (MS)
Matilija Cr.	2,000 – 2,500	Historic	Clanton & Jarvis (1946)
Santa Clara	7,000 – 9,000	Historic	Moore (1980)
	9,000	Historic	Comstock (1992)
	9,000	Historic	Henke (1994)

Recent colonization events

Several colonization events were reported during the interval 1996-2002. Steelhead colonized Topanga Creek in 1998 and San Mateo Creek in 1997 (R. Dagit, T. Hovey, pers. comm.). As of this writing (October 2002) both colonizations persist although the San Mateo Creek colonization appears to be declining. T. Hovey (CDFG, pers. comm.) used genetic analyses to establish that the colonization in San Mateo Creek was made by two spawning pairs in 1997. In the summer of 2002 a dead mature female was found in the channelized portion of the San Gabriel River in the Los Angeles area (M. Larsen, CDFG, pers. comm.). A single live adult was found trapped and over-summering in a small watered stretch of Arroyo Sequit in the Santa Monica Mountains (K. Pipal and D. Boughton, UCSC and NMFS, pers. comm.). The "run sizes" of these colonization attempts are of the same order as recent "run sizes" in the Santa Clara system—namely, less than five adults per year. Each of the four colonization events reported above occurred in a basin in which the presence of steelhead had been documented historically (Titus et al. MS).

Two significant analyses exist: 1) A critical review of the historical run sizes cited in the previous status review, and 2) A few new data on run size and population distribution in three of the larger basins.

Review of historical run sizes

Few quantitative data exist on historical run sizes of southern steelhead. Based on the available information at the time, the previous status review made rough estimates for three of the large river systems (Table B.2.9.1), and a few of the smaller ones (Busby et al. 1996).

The Santa Ynez.—The run size in the Santa Ynez system—probably the largest run historically—was estimated to originally lie between 20,000 and 30,000 spawners (Busby et al. 1996). This estimate was based primarily on four references cited in the status review: Reavis (1991) (20,000-30,000 spawners), Titus et al. (MS) (20,000 spawners), Shapovalov and Taft (1954) (12,995-25,032 spawners), and CDFG (1982) (20,000 spawners). Examination of these references revealed the following: Reavis (1991) asserted a run size of 20,000-30,000, but provided no supporting evidence. Titus et al. (MS) reviewed evidence described by Shapovalov (1944), to be described below. Shapovalov and Taft (1954) did not address run sizes in this geographic region; the citation is probably a mis-citation for Shapovalov (1944). CDFG (1982) makes no reference to salmonid fishes in southern California.

Entrix (1995) argued that the estimate of 20,000 – 30,000 is too large. They argued that the only direct observations of run size are from Shapovalov (1944), an assertion that appears to be correct. These data are based on a CDFG employee's visual estimate that the 1944 run was "at least as large" as runs in the Eel River (northern California), which the employee had observed in previous years. Estimated run sizes for the Eel River ranged between 12,995 and 25,032 during the years 1939 to 1944 (Shapovalov 1944), and this has thus been reported as the estimated run size of the Santa Ynez. Entrix (1995) observed, however, that the employee who made the comparison was only present at the Eel River during two seasons, 1938-39 and 1939-40. The estimates for run sizes in those years were 12,995 and 14,476 respectively, which suggests that a more realistic estimate for the Santa Ynez run of 1944 would be 13,000-14,500. Taking this chain of reasoning to its logical conclusion, the range 13,000 – 14,500 should be regarded as a minimum run size for the year in question, since the employee used the phrase "at least as large."

It is perhaps useful to place the year 1944 in context, since expert opinion about run size is based solely on observations made in that year. Entrix (1995) report that 1944 occurred toward the end of a wet period, which may have provided especially favorable spawning and rearing conditions for steelhead. Rainfall data from Santa Barbara County's historical records give a different picture from Entrix (1995): only two of the preceding eight years (1940 and 1943) were wetter than the 107-year average for the area (M. Capelli, person. comm.). 1944 was near average; otherwise rainfall was below average.

In addition, the year 1944 seems to have occurred toward the end of a period in which extensive rescues of juvenile steelhead had been made during low-flow years (Shapovalov 1944, Titus et al. MS). Over the interval 1939-1946, a total of 4.3 million juveniles were rescued from drying portions of the mainstem, and usually replanted elsewhere in the system. This averages to about 61,400 juveniles rescued per year. Assuming that rescue operations lowered the mean mortality rate as intended, during the 1939-1946 interval the Santa Ynez population may have increased somewhat (or failed to undergo a decline) due to the rescue operations. A rough estimate of magnitude can be made: Assuming deterministic population growth (as opposed to stochastic), and a survival to spawning of about 1%, the rescues would have increased the run size by about 4% per generation. High environmental stochasticity in survival of the rescued fish and in the overall population growth—which almost certainly was the case—would have reduced the effect size to be much lower than 4%.

There is a counter argument to the argument that the 1944 estimate is too high; namely that it is too low. The estimate was not made until 24 years after a significant proportion of spawning and rearing habitat had been blocked behind dams. The Santa Ynez system currently has three major dams on the mainstem that block portions of spawning and rearing habitat. The middle dam (Gibraltar) was built in 1920, and blocked access to 721 kilometers of stream, much of which was widely regarded to be high-quality spawning and rearing habitat (Table B.5.1.1; Titus et al MS). At that time, no estimates of run size had been made for the Santa Ynez. An upper dam (Juncal) was constructed in 1930 and may have had a negative effect on run size through reduction of flows to the lower mainstem. Only the lower dam (Cachuma or Bradbury) was built late enough (1953) to not cause the 1944 estimate to be a biased estimate of historical run size.

Ventura.—According to Titus et al. (MS), the Ventura River was estimated to have a run size of 4,000-5,000 adults during a normal water year. This estimate was made in 1946, although it is likely that the estimate is an expert opinion based on numerous years of observation. The system had received numerous plantings of juveniles in the preceding period (27,200 in 1943, 20,800 in 1944, and 45,440 in 1945, as well as 40,000 in 1930, 34,000 in 1931, and 15,000 in 1938). These rescues probably had small effect, for similar reason as those cited above for the Santa Ynez. As in the Santa Ynez, anecdotal accounts suggest that run sizes declined precipitously during the late 1940s and 1950s, due possibly to both drought and to anthropogenic changes to the river system such as dam construction. Similar considerations apply to the estimate made by Clanton and Jarvis (1946), of 2,000-2,500 adults in the Matilija basin, a major tributary of the Ventura River.

Santa Clara.—Moore's (1980) estimate of 9,000 spawners in the Santa Clara basin is an extrapolation of the estimate of Clanton and Jarvis' (1946) estimate for Matilija Creek. He assumed similar levels of production per stream mile in the two systems, and noted that at least five-times more spawning and rearing habitat exists in the Santa Clara. Moore (1980) regarded his estimate as biased downward, because although it included the major spawning areas (Santa Paula, Sespe, and Piru creeks), it omitted numerous small side-tributaries.

Ed Henke (cited in NMFS 1997) stated that abundance of steelhead in the Southern California ESU was probably about 250,000 adults prior to European settlement of the region. His argument is based on historical methods of research involving interviews of older residents of the area as well as written records. The original analysis producing the cited estimate is part of ongoing research and was not made available for review at the time of this writing (E. Henke, pers. comm.).

In summary, the estimates of historical run sizes for this steelhead ESU are based on very sparse data and long chains of assumptions that are plausible but have not been adequately tested. It seems reasonable to say that the existing estimates are biased upward or downward by some unknown amount. It is certainly clear from the historical record that adult run sizes of the past could be 2 or 3 orders of magnitude greater in size than those of recent years, but the long-term mean or variance in run size is not known with any reasonable precision at all. Assuming that spawning and rearing success are related to rainfall, the variance between years was likely high due to climatic variability in southern California; and variance among decades high due to the Pacific Decadal Oscillation. In addition, long-term climate change in the region likely causes the running mean of run size (whatever it may be) to exhibit drift over time. If one were to be interested in the true potential productivity of these systems, much would be learned by some targeted field studies on the current habitat-productivity relationships for the fish, and by studies of the influence of climate, water management practices, and their interaction. It does not seem likely that further historical research will turn up information useful for making more refined estimates, despite the fact that it is useful for determining where exactly the fish occurred.

Recent run sizes of large river systems

It seems likely that the larger river systems were originally the mainstay of the ESU. Large river systems that harbored steelhead populations in the past are (from north to south) the Santa Maria, the Santa Ynez, the Ventura, the Santa Clara, the Los Angeles, the San Gabriel, the Santa Ana, and possibly the San Diego. Of these eight systems, the data suggest that steelhead currently occur in only four—the Santa Maria, Santa Ynez, Ventura, and Santa Clara.

The Santa Maria—There do not appear to be any estimates for recent run sizes in the Santa Maria system. Twitchell Dam blocks access to a significant proportion of historical spawning habitat, the Cuyama River, one of the two major branches of the Santa Maria. The other major branch, the Sisquoc River, appears to still have substantial spawning and rearing habitat that is accessible from the ocean; juvenile steelhead have recently been observed in these areas (Cardenas 1996, Kevin Cooper, Los Padres NF, pers. comm.).

The Santa Ynez—Most of the historical spawning habitat is blocked by Cachuma and Gibraltar Dams. However, extensive documentation exists for steelhead/rainbow trout populations in a number of ocean-accessible sites below Cachuma dam (Table B.2.9.2). These are Salsipuedes/El Jaro Creeks, Hilton Creek, Alisal Creek, Quiota Creek, San Miguelito Creek, and three reaches in the mainstem (Hanson 1996, Engblom 1997, 1999, 2001). Various life stages of steelhead, including upstream migrants and smolts, have been consistently observed at some of these sites (see Table B.2.9.2), suggesting the occurrence of persistent populations. Run sizes are unknown, but likely small (<100 adults total), implying the populations are not viable over the long term. A third dam, Juncal Dam, occurs above the other two dam in the watershed, and is reported to support a small population of land-locked steelhead that annually enter the reservoirs' tributaries to spawn (M. Capelli, pers. comm.)

The Ventura—There are no estimates of recent run sizes in the Ventura River. Casitas Dam on Coyote Creek and Matilija Dam on Matilija Creek block access to significant portions of the historical spawning habitat. There are recent individual reports of sightings of steelhead in the Ventura River and San Antonio Creek (M Capelli, 1997; C. Zimmerman 2000, 2001), but no quantitative estimates.

The Santa Clara—A few estimates of recent run sizes exist for the Santa Clara system, due to the presence of a fish ladder and counting trap at the Vern Freeman Diversion Dam on the mainstem. This diversion dam lies between the ocean and what is widely believed to be one of the largest extant populations of steelhead in the ESU (the Sespe Canyon population). The run size of upstream migrants was one adult in each of 1994 and 1995, two adults in 1996, and no adults in 1997. No data have been collected since that date, and the fish ladder is thought to be dysfunctional.

Harvest impacts

Since the original status review of Busby et al. (1996), regulations concerning sport fishing have been changed in a way that may potentially reduce extinction risk for the ESU.

Sport harvest of steelhead in the ocean is currently prohibited by the California Department of Fish and Game (CDFG 2002a), and ocean harvest is a rare event (M. Mohr, NMFS, pers. comm.). For freshwaters (CDFG 2002b), summer-fall catch-and-release angling is allowed in Piru Creek below the dam; San Juan Creek (Orange County); San Mateo Creek (one section); Santa Margarita River and tributaries; and Topanga Creek. Year-round catch and release is allowed in the San Gabriel River (below Cogswell Dam); and Sespe Creek and tributaries. All the above are historical steelhead streams and many of the stretches open to fishing are potentially used both by anadromous runs and by resident populations.

Year-round trout fisheries are allowed in Calleguas Creek and tributaries (limit 5); Piru Creek above the dam (limit 2); San Luis Rey River (limit 5); Santa Paula Creek above the falls (limit 5); the Santa Ynez River above Gibraltar Dam (limit 2); Sisquoc River (limit 5); and Sweetwater River (limit 5). With the exception of the Sisquoc River, these take-fisheries appear to be isolated from the ocean by natural or human-made barriers. Except for Calleguas Creek and possibly the Sweetwater, the above drainages are listed as historical steelhead streams by Titus et al. (MS). It is certainly possible and indeed likely that some currently harbor native trout with the potential to exhibit anadromy

At catch-and-release streams, all wild steelhead must be released unharmed. There are significant restrictions on gear used for angling. The CDFG monitors angling effort and catch-per-unit-effort in selected basins by way of a "report card" system in which sport anglers self-report their catch, gear used, and so forth, and in selected other basins by way of creel censuses.

Although the closure of many areas, and institution of catch-and-release elsewhere, is expected to reduce extinction risk for the ESU, this risk reduction cannot be estimated quantitatively from the existing datasets (due to the fact that natural abundance is not being estimated). After the Federal listing decisions, NMFS requested that CDFG prepare a Fishery Management and Evaluation Plan (FMEP) for the listed steelhead ESUs in California. This has not yet been done for the southern California ESU, so the rationale for the set of regulations summarized above is not transparent.

Resident *O. mykiss* considerations

Resident (non-anadromous) populations of *O. mykiss* were assigned to one of three categories for the purpose of provisionally determining ESU membership (See "Resident Fish" in the introduction for a description of the three categories and default assumptions about ESU membership). The third category consists of resident populations that are separated from anadromous conspecifics by recent human-made barriers such as dams without fish ladders. No default assumption about ESU membership was possible for Category 3 populations, so they are here considered case-by-case according to available information.

As of this writing there are few data on occurrence of resident populations and even fewer on genetic relationships. A provisional survey of the occurrence of Category 3 populations in the ESU (see Table B.5.1.1) revealed the following: There are numerous Category 3 populations within the original geographic range of the Southern California ESU. All of the larger watersheds originally inhabited by the ESU now have major barriers completely blocking substantial portions of habitat (Table B.5.1.1; a major barrier is defined as a complete barrier to migration that has greater than 100 sq. mi. of watershed area lying above it). In the watershed of the Santa Maria River, 71% of total stream kilometers are above Twitchell Dam. The Santa Clara watershed has 99% of stream kilometers above Vern Freeman diversion dam. This facility has a fish ladder, but the ladder is currently dysfunctional due to channel migration which has disconnected the ladder intake from the river's thalweg, combined with deficient quantities and configurations of water releases through the facility (M. Whitman, CDFG hydraulic engineer, personal communication). The Santa Ynez watershed, which probably originally harbored the strongest run of steelhead in the southern California ESU, has 58% of its stream kilometers above Cachuma dam. In each of these cases the historical record has reports of steelhead ascending to and spawning in areas that are now blocked behind the above-mentioned dams (Titus et al. 2003). In the case of the Santa Ynez, adult *O. mykiss* have been observed to make "steelhead-like" runs from the uppermost reservoir (behind Juncal dam) into the North Fork Juncal and the upper Santa Ynez for at least the past seven years (personal communication, Louis Andolora, dam tender at Juncal).

All the large watersheds further south have major barriers blocking substantial portions of stream habitat. Consequently, in the set of major watersheds originally inhabited by the ESU, at least 48% of stream kilometers are now behind barriers impassable to anadromous fish (the value is probably somewhat higher due to minor barriers not considered in Table B.5.1.1). At least 11 of these 15 major watersheds are known to have resident populations above the barriers (Table B.5.1.1).

We do not know much about the genetic relationships of these resident populations. There is one study of genetic relationships among hatchery stocks, anadromous fish, and resident populations above barriers (Nielsen et al. 1997). The study used selectively-neutral genetic markers to assess genetic distances among the various categories of fish (anadromous, residualized, hatchery, etc.) but the results were inconclusive. However, according to the provisional survey described in Table B.5.1.1, at least 7 of the 11 watersheds with resident populations above major barriers are currently being stocked with hatchery fish. It is not clear whether these stocked fish have successfully interbred with the native fish; whether such interbreeding would have led to significant gene flow between the introduced and native fish; or to what extent the local adaptations of the native fish would have been maintained by selection even if gene flow occurred.

Table B.2.9.2. Presence of steelhead in the lower Santa Ynez River system (*caught in upstream migrant trap).

Tributary	Redds	<6"	>6"	Smolts	Adults	Unspec	Year (spr.)	Source
Salsipuedes/El Jaro		Y	Y	Y	Y*		1994	Hanson 1996
				Y	Y*		1995	Hanson 1996
	Y	Y	Y	Y	Y*		1996	Hanson 1996, Engblom 1997
	Y	Y	Y	Y	Y*		1997	Engblom 1997
	Y	Y	Y		Y*		1998	Engblom 1999
	Y	Y	Y		Y*		1999	Engblom 1999
					Y*		2000	Engblom 2001
		Y	Y	Y	Y*		2001	Engblom 2001
Hilton Creek		N	N		Y*		1994	Hanson 1996
		Y	Y[†]	Y	Y*		1995	Hanson 1996
				N	Y*		1996	Hanson 1996, Engblom 1997
	N	Y	Y	N	Y*		1997	Engblom 1997
	Y	Y			Y*		1998	Engblom 1999
					N*		1999	Engblom 1999
		Y	Y		Y*		2001	Engblom 2001
Alisal Creek		Y	Y		Y*		1995	Hanson 1996
Nojoqui Creek		N	N		N*		1994	Hanson 1996
				N	N*		1995	Hanson 1996
				N			1997	Engblom 1997
		N	Y		Y*		1998	Engblom 1999
					N*		1999	Engblom 1999
Quiota Creek (& trib)	Y		Y		N*		1995	Hanson 1996
		Y	Y				1994	Hanson 1996
		Y					1998	Engblom 1999
		Y	Y				2001	Engblom 2001
San Miguelito Creek		Y	Y				1996	Hanson 1996
	Y			Y			1997	Engblom 1997
		Y		N	N*		1998	Engblom 1999
	Y			N	N*		1999	Engblom 1999
Mainstem/Hwy 154		Y	Y				1995	Hanson 1996
		Y	Y				1996	Hanson 1996
					Y		1994	Hanson 1996
		Y	Y				1998	Engblom 1999
	Y						1999	Engblom 1999
		Y	Y				2001	Engblom 2001
Mainstem/Refugio		Y	Y				1995	Hanson 1996
		N	Y				1996	Hanson 1996
		Y	Y				1998	Engblom 1999
	Y	N	Y				1999	Engblom 1999
		Y	Y				2001	Engblom 2001
Mainstem/Alisal reach		Y	Y				1995	Hanson 1996
		N	Y				1996	Hanson 1996
		Y	Y				1998	Engblom 1999
		Y	Y				1999	Engblom 1999
		Y	Y				2001	Engblom 2001
Mainstem/Cargasachi		N	N				1995	Hanson 1996
		N	N				1996	Hanson 1996

B.2.10 CALIFORNIA CENTRAL VALLEY STEELHEAD

Primary contributor: Steve Lindley
(Southwest Fisheries Science Center - Santa Cruz Lab)

B.2.10.1 Summary of Previous BRT Conclusions

Summary of major risk factors and status indicators

Steelhead were once widespread throughout the Central Valley (CACSS, 1998; Reynolds et al. 1993). Steelhead require cool water in which to oversummer, and much of this habitat is now above impassable dams. Where steelhead are still extant, natural populations subject to habitat degradation, including various effects of water development and land use practices. Concerns of the BRT included extirpation from most of historical range, a monotonic decline in the single available time series of abundance (Table B.2.10.1; Figure B.2.10.1), declining proportion of wild fish in spawning runs, substantial opportunity for deleterious interactions with hatchery fish (including out-of-basin origin stocks), various habitat problems, and no ongoing population assessments. Compared to most chinook salmon populations in the Central Valley, steelhead spawning above Red Bluff Diversion Dam (RBDD) had a fairly strong negative population growth rate and small population size at the time of last census (1993) (Figure B.2.10.2).

Table B.2.10.1. Summary statistics for Central Valley steelhead trend analyses. Numbers in parentheses are 0.90 confidence intervals. Threatened and endangered chinook salmon populations are shown for comparison. Note that for steelhead, the 5-yr geometric mean refers to the period ending in 1993. There is insufficient recent data to calculate a short-term trend in abundance.

Population	5-yr mean	5-yr min	5-yr max	λ	μ	LT trend	ST trend
Sacramento River steelhead	1,952	1,425	12,320	0.95 (0.90, 1.02)	-0.07 (-0.13, 0.00)	-0.09 (-0.13, -0.06)	NA
Sacramento River winter chinook	2,191	364	65,683	0.97 (0.87, 1.09)	-0.10 (-0.21, 0.01)	-0.14 (-0.19, -0.09)	0.26 (0.04, 0.48)
Butte Creek spring chinook	4,513	67	4,513	1.30 (1.09, 1.60)	0.11 (-0.05, 0.28)	0.11 (0.03, 0.19)	0.36 (0.03, 0.70)
Deer Creek spring chinook	1,076	243	1,076	1.17 (1.04, 1.35)	0.12 (-0.02, 0.25)	0.11 (0.02, 0.21)	0.16 (-0.01, 0.33)
Mill Creek spring chinook	491	203	491	1.19 (1.00, 1.47)	0.09 (-0.07, 0.26)	0.06 (-0.04, 0.16)	0.13 (-0.07, 0.34)

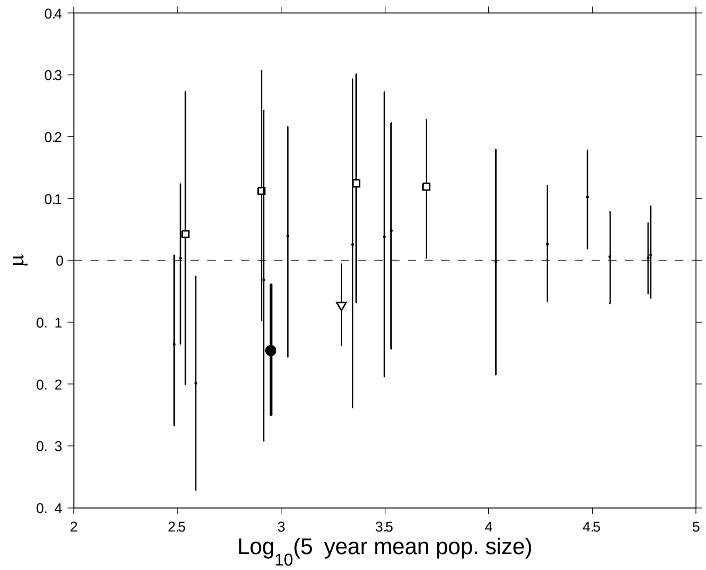


Figure B.2.10.1. Abundance and growth rate of Central Valley salmonid populations. Large filled circle- steelhead above RBDD; open squares- spring chinook; open triangle- winter chinook; small black dots- other chinook stocks (mostly fall runs). Error bars represent central 0.90 probability intervals for μ estimates. (Note: as defined in other sections of the status reviews, μ ≈log [λ].)

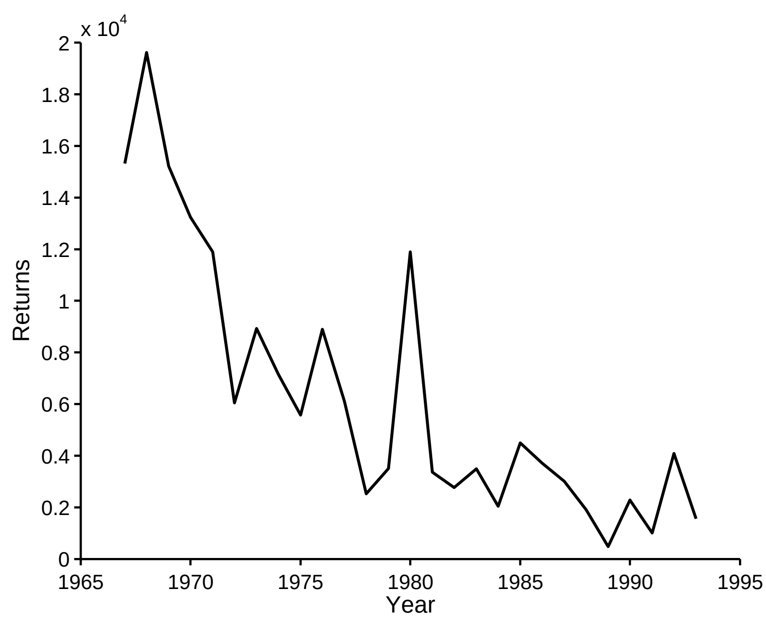


Figure B.2.10.2. Counts of steelhead passing the Red Bluff Diversion Dam fish ladders. These fish include hatchery fish from Coleman NFH.

Previous BRT Conclusions

The BRT previously concluded that the Central Valley ESU was in danger of extinction (Busby et al. 1996), and this opinion did not change in two status review updates (NMFS 1997; NMFS 1998a). The Nimbus Hatchery and Mokelumne River Hatchery steelhead stocks were excluded from the Central Valley ESU (NMFS 1998b).

Listing status

The Central Valley steelhead ESU was listed as Threatened on March 19, 1998.

B.2.10.2 New Data and Updated Analyses

Historic distribution and abundance

McEwan (2001) reviewed the status of Central Valley steelhead. Steelhead probably occurred from the McCloud River and other northern tributaries to Tulare Lake and the Kings River in the southern San Joaquin Valley. McEwan also guessed that more than 95% of historical spawning habitat is now inaccessible. He did not hazard a guess about current abundance. He guessed, on the basis of the fairly uncertain historical abundance estimates of Central Valley chinook reported by Yoshiyama et al. (1998), that between 1 million and 2 million steelhead may have once spawned in the Central Valley. McEwan's estimate is based on the observation that presently, steelhead are found in almost all systems where spring-run chinook salmon occur and can utilize elevations and gradients even more extreme than those used by spring chinook, as well as mid-elevation areas not used by spring chinook. Steelhead should therefore have had more freshwater habitat than spring chinook, and the sizes of steelhead populations should therefore have been roughly comparable those of spring chinook.

Current Abundance

One source of new abundance information since the last status review comes from midwater trawling below the confluence of the Sacramento and San Joaquin Rivers at Chipps Island. This trawling targets juvenile chinook; catches of steelhead are incidental. In a trawling season, over 2,000 20-minute tows are made. Trawling occurred from the beginning of August through the end of June in 1997/98 and 1998/99, after which trawling has occurred year-round. Usually, 10 tows are made per day, and trawling occurs several days per week.

Since the 1998 broodyear, all hatchery steelhead have been ad-clipped. Trawl catches of steelhead provide an estimate of the proportion of wild to hatchery fish, which, combined with estimates of basin-wide hatchery releases, provide an estimator for wild steelhead production:

$$N_w = \frac{C_w}{C_h} N_h \qquad (1)$$

where N_w is the number of wild steelhead, C_w and C_h are the total catches of wild and hatchery steelhead, and N_h is the number of hatchery fish released. The accuracy of the estimate depends on the assumption that hatchery and natural steelhead are equally vulnerable to the trawl gear. In particular, if hatchery fish are more vulnerable to the gear, natural production is underestimated.

Catches of steelhead are sporadic—most sets catch no steelhead, but a few sets catch up to four steelhead. To estimate the mean and variance of C_w / C_h, the trawl data sets were resampled with replacement 1,000 times. The mean C_w / C_h ranged from 0.06 to 0.30, and coefficients of variation ranged from 16% to 37% of the means.

From such calculations, it appears that about 100,000-300,000 steelhead juveniles (roughly, smolts) are produced naturally each year in the Central Valley (Table B.2.10.2). If we make the fairly generous assumptions (in the sense of generating large estimates of spawners) that average fecundity is 5,000 eggs per female, 1% of eggs survive to reach Chipps Island, and 181,000 smolts are produced (the 1998-2000 average), about 3,628 female steelhead spawn naturally in the entire Central Valley. This can be compared with McEwan's (2001) estimate of 1million-2 million spawners before 1850, and 40,000 spawners in the 1960s. Table B.2.10.2 shows the effects of different assumptions about survival on estimates of female spawner abundance.

Table B.2.10.2. Estimated natural production of steelhead juveniles from the Central Valley. C_w/C_h = ratio of unclipped to clipped steelhead; N_r = total hatchery releases; N_w = estimated natural production; ESS = egg-to-smolt survival.

				wild female spawners		
Year	C_w/C_h	N_r (millions)	N_w (thousands)	ESS=1%	ESS=5%	ESS=10%
1998	0.300	1.12	336	6,720	1,344	672
1999	0.062	1.51	94	1,872	374	187
2000	0.083	1.38	115	2,291	458	229
average	0.148	1.34	181	3,628	726	363

Another source of information comes from screw trap operations at Knights Landing on the lower Sacramento River, just above the confluence of the Feather River (Snider and Titus 2000a, 2000b, 2000c). Over the period 1995-1999, estimates of the natural production for the areas above Knights Landing averaged 9,800 yearling steelhead outmigrants (range 7260-11,700). This level of production is about 5% of the total production as estimated above, and may be a substantial underestimate due to application of trap efficiency estimates generated from recaptures of marked chinook juveniles, which probably are less able to avoid traps.

Nobriga and Cadrett (2001) analyzed captures of steelhead in trawls at Chipps Island and in fish salvage facilities associated with water diversions in the southern Delta. They computed average daily catch of hatchery and wild steelhead per unit effort, and used these estimates to estimate the percentage of hatchery fish. They found that hatchery steelhead comprised 63-77% of the trawl catch of steelhead at Chipps Island (compared to 77-92% estimated from the resampling method described above), and generally lower percentages in the south Delta, which is not surprising since the bulk of hatchery production comes out of Sacramento River basin. This alternative analysis of the Chipps Island trawl data suggests that wild steelhead are roughly three-fold more abundant than the resampling analysis discussed above.

Current Distribution

Recent spawner surveys of small Sacramento River tributaries (Mill, Deer, Antelope, Clear, and Beegum Creeks, Moore 2001) and incidental captures of juvenile steelhead during chinook monitoring (Calaveras, Cosumnes, Stanislaus, Tuolumne, and Merced Rivers) have confirmed that steelhead are widespread, if not abundant, throughout accessible streams and rivers. Much of this information is reviewed by McEwan (2001). Figure B.2.10.3 cartographically summarizes the information on distribution of steelhead in Central Valley streams; details are listed in Table B2.10.3.

CDFG (2003) reported trawl captures of *O. mykiss* at Mossdale on the lower San Joaquin River (below confluence of the Tuolumne, Stanislaus and Merced Rivers). Because the Mossdale area is not suitable habitat for resident *O. mykiss*, these fish are assumed to be steelhead smolts. Between 2 and 30 fish per year were captured in the 1988-2002 period. Rotary screw trap data suggests that the bulk of this production comes from the Stanislaus, although some smolts were captured in the Merced and Tuolumne as well.

Resident *O. mykiss* considerations

Coastal *O. mykiss* is widely distributed in the Central Valley basin. Roughly half of the trout habitat (by area) in the Central Valley is above dams that are impassable to fish; higher elevation habitats appear to support quite high densities of trout, ranging from a few hundred to a few thousand 4”—6” fish per km (see Appendix B.5.2).

There are several areas of substantial uncertainty that make interpreting this information difficult. First, it is not clear how anadromous and non-anadromous coastal *O. mykiss* interacted in the Central Valley before the dam-building era. In other systems, anadromous and non-anadromous *O. mykiss* forms can exist within populations, while in other systems, these groups can be reproductively isolated despite nearly sympatric distributions within rivers (Zimmerman and Reeves, 2000). Second, hatchery produced *O. mykiss* have been widely stocked throughout the Central Valley, Sierra Nevada and southern Cascades. It is possible that this stocking has had deleterious effects on native wild trout populations, although limited information indicates that native trout populations remain in some areas that have received stocked fish (Nielsen et al. 2000).

We suspect that some coastal *O. mykiss* populations that are above man-made barriers could be part of the Central Valley ESU, because these populations were probably exhibiting some degree of anadromy and interacting with each other on evolutionary time scales prior to barrier construction. Due to a lack of data, we cannot, however, identify any particular resident populations as part of the Central Valley ESU.

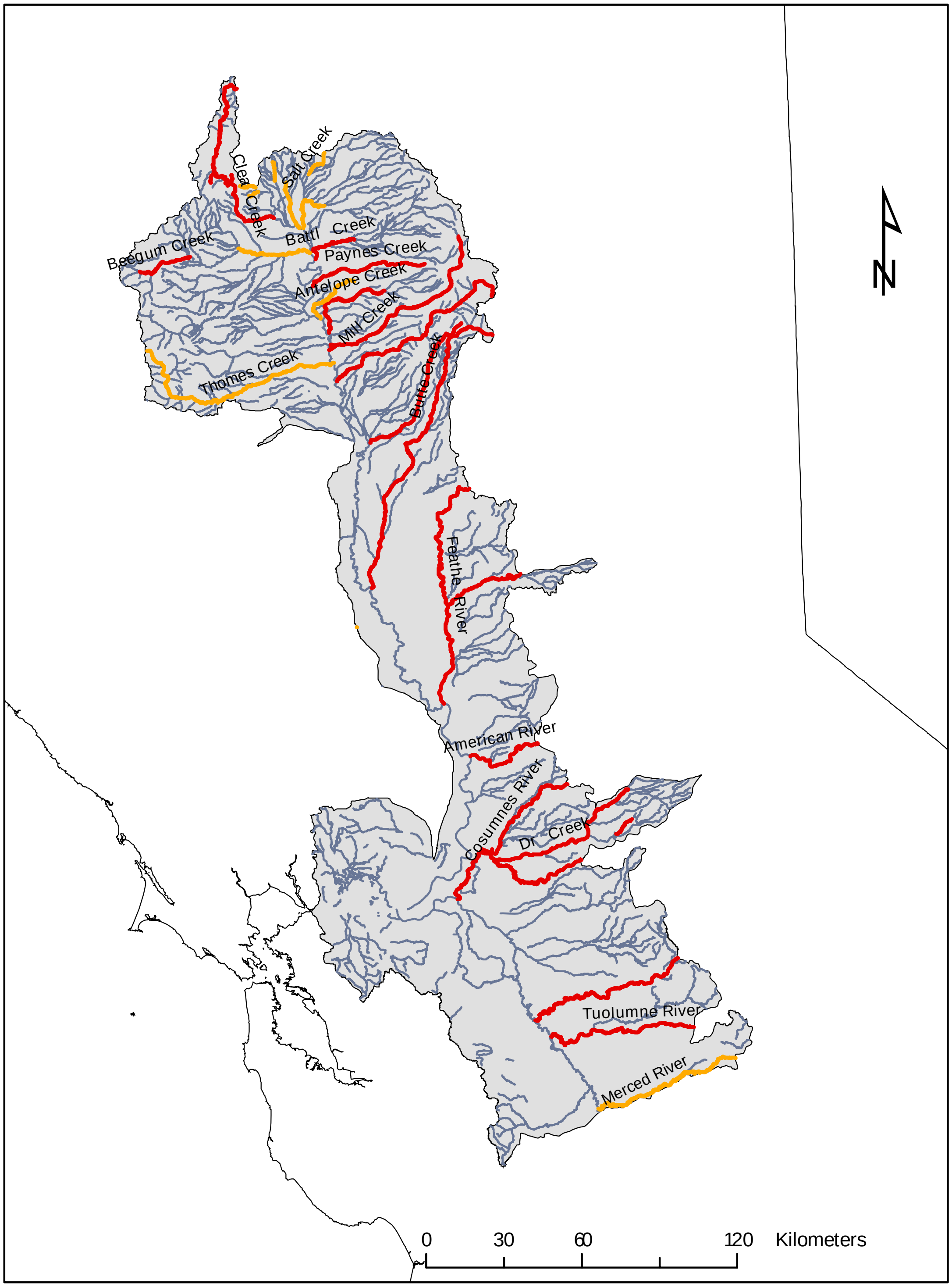


Figure B.2.10.3. Central Valley tributaries known (dark gray lines; bold font) or suspected (medium gray lines; normal font) to be used by steelhead adults. Kerrie Pipal (NMFS Santa Cruz Lab) assembled this information from agency and consultant reports and discussions with CDFG field biologists.

Table B.2.10.3. Summary of distribution information for steelhead in the Central Valley.

System	Tributary	Current presence	Most recent documented date of presence	Count / Life Stage	Comments	Source
Sacramento River	Clear Creek	Yes	2001	Adults/Juvs	Snorkel surveys and redd counts, rotary screw traps	Jess Newton (USFWS), personal communication, Aug 2002
	Rock Creek	Probable	2001	Adults/Juvs	Creek used for spawning	Mike Berry (CDFG), personal communication, Oct 2002.
	Salt Creek	Probable	2001	Adults/Juvs	Possible spawning; non-natal rearing	ibid
	Sulphur Creek	Probable	2001	Adults/Juvs	Creek used for spawning	ibid
	Olney Creek	Probable	2001	Adults/Juvs	Spawning, non-natal rearing	ibid
	Stillwater Creek	Probable	-	-	Non-natal rearing	ibid, Maslin 1998.
	Cow Creek + tribs	Probable	1992	-	Suitable habitat, access problems	CDFG 1993
	Cottonwood Creek	Probable	-	-		CDFG 1993
	Beegum Creek	Yes	2001	Adults		Moore 2001.
	South Fork Cottonwood Creek	Possible	-	-	Large populations of 'rainbow trout'	Mike Berry (CDFG), personal communication, Oct 2002.
	Bear Creek	Possible	-	-		CDFG 1993
	Battle Creek	Yes	2002	-		Kier & Associates 2001. Jess Newton (USFWS), personal communication, Aug 2002.
	Paynes Creek	Yes	2002	Adults	Self-sustaining population unlikely	Mike Berry (CDFG), personal communication, Oct 2002.
	Antelope Creek	Yes	2001	Adults + redds		Moore 2001.
	Mill Creek	Yes	2001	Adults + redds	Small numbers counted.	Moore 2001.
	Elder Creek	Possible	No recent surveys	-	Resident trout present	CDFG 1993

	Thomes Creek	Probable	1969 & 2002	-	Used by chinook, "trout" observed	Puckett 1969, Killam 2002, Mike Berry (CDFG), personal communication, Oct 2002.
	Deer Creek	Yes	2001	Adults + redds		Moore 2001
	Rice Creek	Yes	1998	Juveniles		Maslin 1998
	Big Chico Creek	Yes	-	-		CDFG 1993
	Butte Creek	Yes	2000	-	Report confirms steelhead presence, no details.	USFWS 2000
	Feather River	Yes	1998	YOY + Juvs	Screw trap captures	CDWR 1998
	Yuba River	Yes	1998	-	Report confirms steelhead presence, no details.	IEP 1998
	Deer Creek (Yuba trib)	Yes	1993	Adults	Dive survey	StreamNet database
	Dry Creek	Yes	-	-	Secret and Miners Ravines	R. Titus, CDFG
	American River	Yes	2002	Adults + redds	Counted redds, estimated number of adults based on redd counts.	Hannon and Healey 2002.
	Putah Creek	Yes	2000	-	Very small numbers of adult steelhead make their way to the base of Monticello dam	P. Moyle (UC Davis) public communication http://wdsroot.ucdavis.edu/clients/pcbr/book/04_Lake_Solano/04_04_moyle_fish_lowpc.html
San Joaquin River	Cosumnes River	Yes	1995	-	Smolts salvaged from drying pools	Nobriga 1995
	Mokelumne River	Yes	2001	Adults + juveniles		Workman 2001
	Calaveras River	Yes	2001	Adults + juveniles	Several reports list presence, but do not give any details; angler reports/photos.	Gonzalo Castillo, USFWS personal communication
	Stanislaus River	Yes	2001	YOYs & 1+		Kennedy 2002.
	Tuolumne River	Yes	2001	Juvs	Incidental rotary screw trap captures	CDFG 2003
	Merced River	Possible	2002	Juvs	Incidental rotary screw trap captures, large trout caught be anglers, enter hatchery	David Vogel (NRC), personal communication, June 2002. Michael Cozart (Merced River Hatchery), personal communication, Sept 2002.

Harvest Impacts

Steelhead are caught in freshwater recreational fisheries, and CDFG estimates the number of fish caught. Because the sizes of Central Valley steelhead populations are unknown, however, the impact of these fisheries is unknown. According to CDFG creel census, the great majority (93%) of steelhead catches occur on the American and Feather Rivers, sites of steelhead hatcheries (CDFG 2001). In 2000, 1,800 steelhead were retained and 14,300 were caught and released. The total number of steelhead contacted might be a significant fraction of basin-wide escapement, so even low catch-and-release mortality may pose a problem for wild populations. Additionally, steelhead juveniles may be affected by trout fisheries on some tributaries and the mainstem Sacramento.

The State of California's proposed Fishery Management and Evaluation Plan (part of the requirements to obtain ESA coverage for in-river sport fisheries) was recently rejected by NMFS mostly because of the inadequacy of existing and proposed monitoring of fisheries impacts.

B.2.10.3 New Hatchery Information

There is little new information pertaining to hatchery stocks of steelhead in the Central Valley. Figures B.2.10.4 and B.2.10.5 show the releases and returns of steelhead to and from Central Valley hatcheries. As discussed above in the section on new abundance information, hatchery steelhead juveniles dominate catches in the Chipps Island trawl, suggesting that hatchery production is large relative to natural production. Note that Mokelumne River Hatchery and Nimbus Hatchery stocks are not part of the CV ESU due to broodstock source and genetic, behavioral, and morphological similarity to Eel River stocks. Categorization of Central Valley steelhead hatchery stocks (SSHAG 2003) can be found in Appendix B.5.3.

B.2.10.4 Comparison with Previous Data

The few new pieces of information do not indicate a dramatic change in the status of the Central Valley ESU. The Chipps Island trawl data suggest that the population decline evident in the RBDD counts and the previously noted decline in the proportion of wild fish is continuing. The fundamental habitat problems are little changed, with the exception of some significant restoration actions on Butte Creek. There is still a nearly complete lack of steelhead monitoring in the Central Valley.

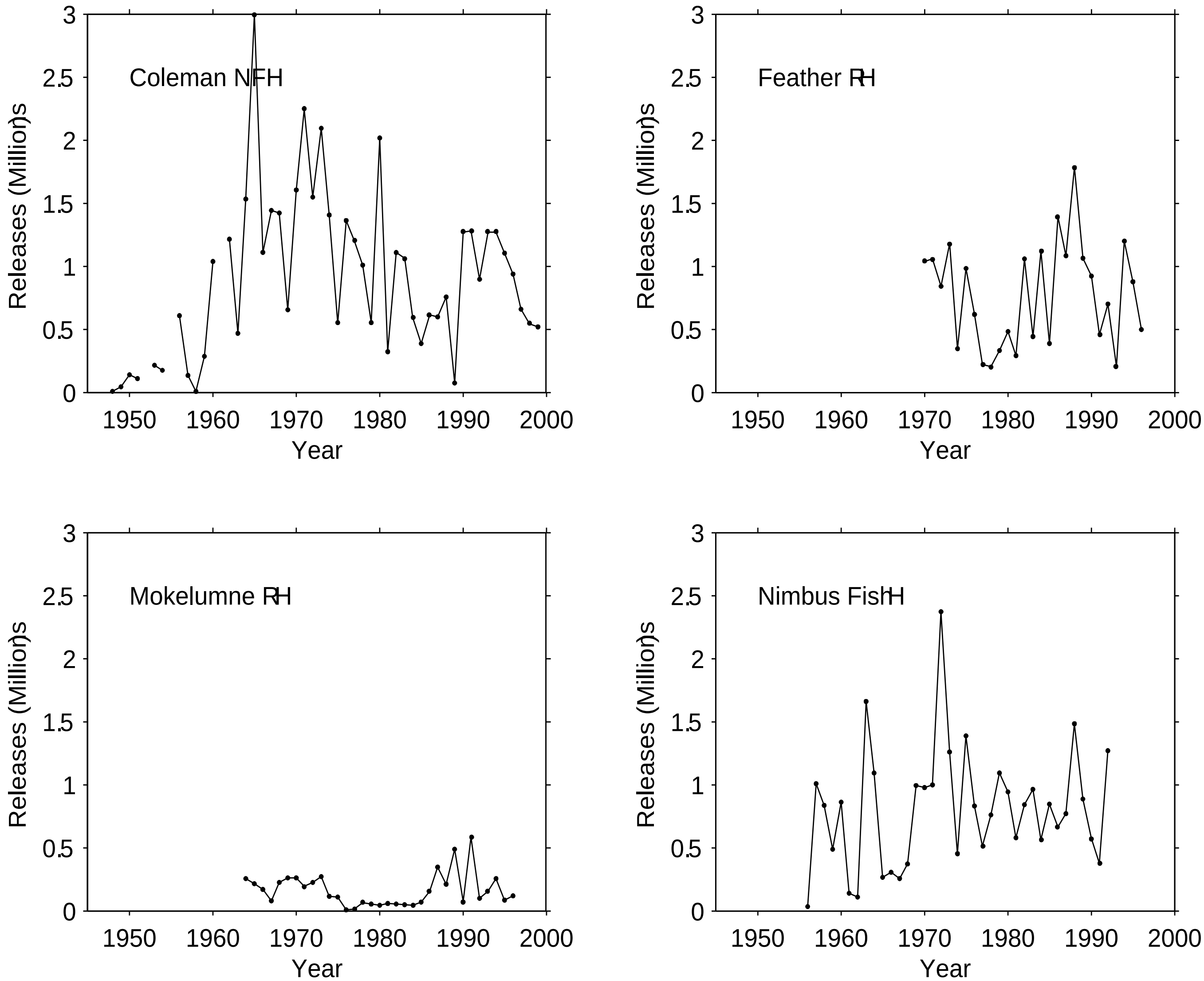


Figure B.2.10.4. Releases of steelhead from Central Valley hatcheries

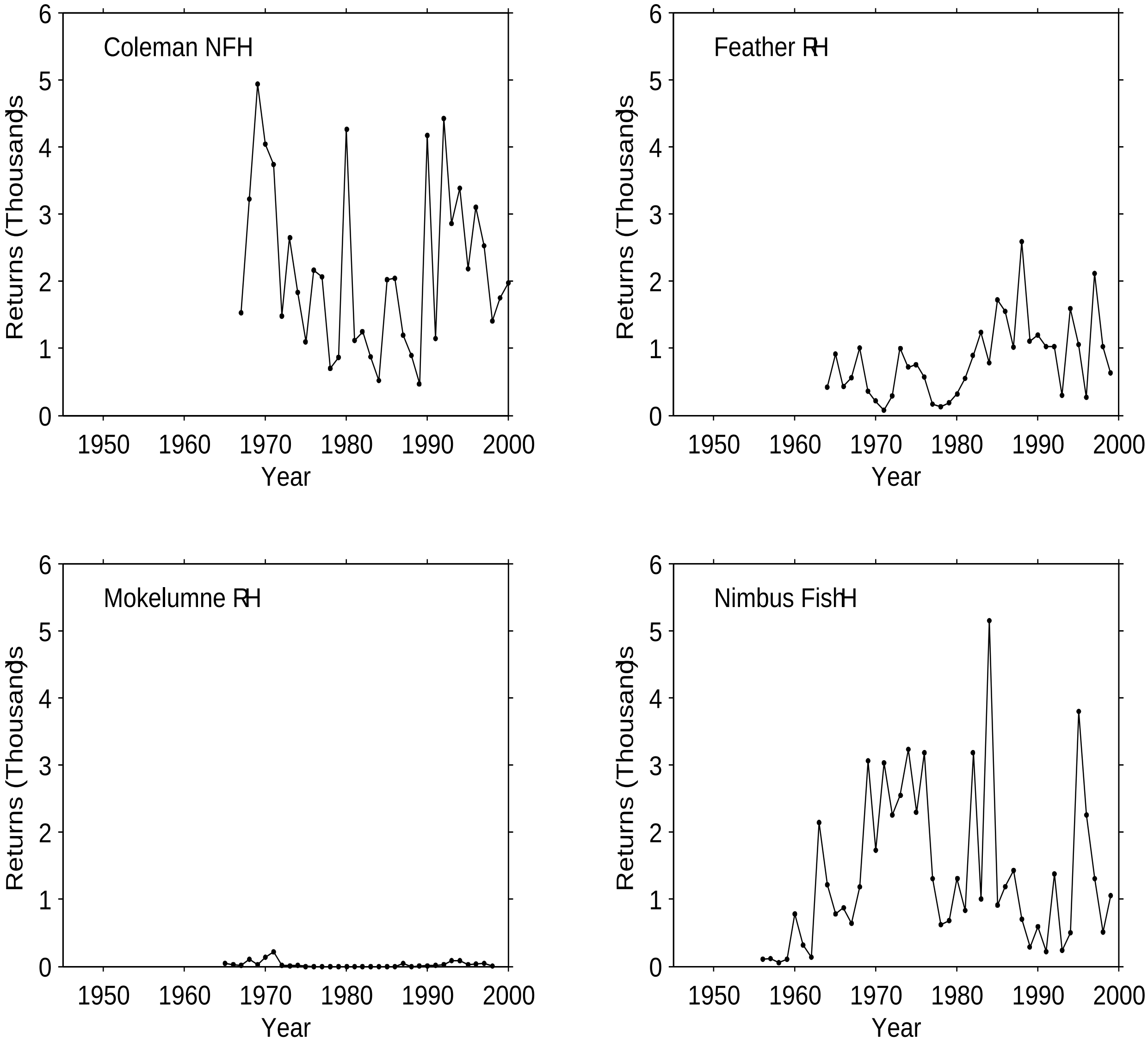


Figure B.2.10.5. Returns of steelhead to Central Valley hatcheries.

B.3 STEELHEAD BRT CONCLUSIONS

The ESA (Sec. 3) allows listing of "species, subspecies, and distinct population segments." The option to list subspecies is not available for Pacific salmon, since no formally recognized subspecies exist. However, a number of subspecies have been identified for *O. mykiss*, including two that occur in North America and have anadromous populations. According to Behnke (1992), *O. mykiss irideus* (the "coastal" subspecies) includes coastal populations from Alaska to California (including the Sacramento River), while *O. mykiss gairdneri* (the "inland" subspecies) includes populations from the interior Columbia, Snake and Fraser Rivers. Both subspecies thus include populations within the geographic range of this updated status review, but both also include northern populations outside the geographic range considered here. The BRT did not attempt to evaluate extinction risk to *O. mykiss* at the species or subspecies level; instead, we evaluated risk at the distinct population segment (ESU) level, as for the other species considered in this report.

Snake River steelhead ESU

A majority (over 70%) of the BRT votes for this ESU fell in the "likely to become endangered" category, with small minorities falling in the "danger of extinction" and "not likely to become endangered" categories (Table B.3.1). The BRT did not identify any extreme risks for this ESU but found moderate risks in all the VSP categories (mean risk matrix scores ranged from 2.5 for spatial structure to 3.2 for growth rate/productivity) (Table B.3.2). The continuing depressed status of B-run populations was a particular concern. Paucity of information on adult spawning escapements to specific tributary production areas makes a quantitative assessment of viability for this ESU difficult. As indicated in previous status reviews, the BRT remained concerned about the replacement of naturally produced fish by hatchery fish in this ESU; naturally produced fish now make up only a small fraction of the total adult run. Again, lack of key information considerably complicates the risk analysis. Although several large production hatcheries for steelhead occur throughout this ESU, relatively few data exist regarding the numbers and relative distribution of hatchery fish that spawn naturally, or the consequences of such spawnings when they do occur.

On a more positive note, sharp upturns in 2000 and 2001 in adult returns in some populations and evidence for high smolt-adult survival indicate that populations in this ESU are still capable of responding to favorable environmental conditions. In spite of the recent increases, however, abundance in most populations for which there are adequate data are well below interim recovery targets (NMFS 2002).

Based on the provisional framework discussed in the general Introduction to this report, the BRT assumed as a working hypothesis that resident fish below historical barriers are part of this ESU, while those above long-standing natural barriers (e.g., in the Palouse and Malad Rivers) are not. Recent genetic data suggest that native resident *O. mykiss* above Dworshak Dam on the North Fork Clearwater River should be considered part of this ESU, but hatchery rainbow trout that have been introduced to that and other areas would not. The BRT did not attempt to resolve the ESU status of resident fish residing above the Hell's Canyon Dam complex, as little new information is available relevant to this issue. However, Kostow (2003) suggested that, based on substantial ecological differences in habitat, the anadromous *O. mykiss* that historically occupied basins upstream of Hells Canyon (e.g., Powder, Burnt, Malheur, Owhyee rivers) may have been in a separate ESU. For many BRT members, the presence of relatively numerous resident fish mitigated the assessment of extinction risk for the ESU as a whole.

Upper Columbia River steelhead ESU

A slight majority (54%) of the BRT votes for this ESU fell in the “danger of extinction” category, with most of the rest falling in the “likely to become endangered” category (Table B.3.1). The most serious risk identified for this ESU was growth rate/productivity (mean score 4.3); scores for the other VSP factors were also relatively high, ranging from 3.1 (spatial structure) to 3.6 (diversity) (Table B.3.2). The last 2-3 years have seen an encouraging increase in the number of naturally produced fish in this ESU. However, the recent mean abundance in the major basins is still only a fraction of interim recovery targets (NMFS 2002). Furthermore, overall adult returns are still dominated by hatchery fish, and detailed information is lacking regarding productivity of natural populations. The ratio of naturally produced adults to the number of parental spawners (including hatchery fish) remains low for upper Columbia steelhead. The BRT did not find data to suggest that the extremely low replacement rate of naturally spawning fish (estimated adult: adult ratio was only 0.25-0.3 at the time of the last status review update) has improved substantially.

Based on the provisional framework discussed in the general Introduction to this report, the BRT assumed as a working hypothesis that resident fish below historical barriers are part of this ESU, while those above long-standing natural barriers (e.g., in the Entiat, Methow, and perhaps Okanogan basins) are not. Resident fish potentially occur in all areas in the ESU used by steelhead. Case 3 resident fish above Conconully Dam are of uncertain ESU affinity. The BRT did not attempt to resolve the ESU status of resident fish residing above Grand Coulee Dam, as little new information is available relevant to this issue. Possible ESU scenarios for these fish include 1) they were historically part of the ESU and many of the remnant resident populations still are part of this ESU; 2) they were historically part of the ESU but no longer are, due to either introductions of hatchery rainbow trout or rapid evolution in a novel environment; or 3) they were historically part of a separate ESU. For many BRT members, the presence of relatively numerous resident fish mitigated the assessment of extinction risk for the ESU as a whole.

Middle Columbia River steelhead ESU

A slight majority (51%) of the BRT votes for this ESU fell in the “likely to become endangered” category, with a substantial minority (49%) falling in the “not likely to become endangered” category (Table B.3.1). The BRT did not identify any extreme risks for this ESU but found moderate risks in all the VSP categories (mean risk matrix scores ranged from 2.5 for diversity to 2.7 for abundance) (Table B.3.2).

This ESU proved difficult to evaluate for two reasons. First, the status of different populations within the ESU varies greatly. On the one hand the abundance in two major basins, the Deschutes and John Day, is relatively high and over the last five years is close to or slightly over the interim recovery targets (NMFS 2002). On the other hand, steelhead in the Yakima basin, once a large producer of steelhead, remain severely depressed (10% of the interim recovery target), in spite of increases in the last 2 years. Furthermore, in recent years escapement to spawning grounds in the Deschutes River has been dominated by stray, out-of-basin (and largely out-of-ESU) fish—which raises substantial questions about genetic integrity and productivity of the Deschutes population. The John Day is the only basin of substantial size in which production is clearly driven by natural spawners. For the other major basin in the ESU (the Klickitat), no quantitative abundance information is available. The other difficult issue centered on how to evaluate contribution of resident fish, which according to Kostow (2003) and other sources are very common in this ESU and may greatly outnumber anadromous fish. The BRT concluded that the relatively abundant and widely distributed resident fish mitigated extinction risk in this ESU somewhat. However, due to significant threats to the anadromous component the majority of BRT members concluded the ESU was likely to become endangered.

Historically, resident fish are believed to have occurred in all areas in the ESU used by steelhead, although current distribution is more restricted. Based on the provisional framework discussed in the general Introduction to this report, the BRT assumed as a working hypothesis that resident fish below historical barriers are part of this ESU, while those above long-standing natural barriers (e.g., in Deschutes and John Day basins) are not. Case 3 resident fish above Condit Dam in the Little White Salmon; above Pelton and Round Butte Dams (but below natural barriers) in the Deschutes; and above irrigation dams in the Umatilla Rivers are of uncertain ESU status.

Lower Columbia River steelhead ESU

A large majority (over 79%) of the BRT votes for this ESU fell in the "likely to become endangered" category, with small minorities falling in the "danger of extinction" and "not likely to become endangered" categories (Table B.3.1). The BRT found moderate risks in all the VSP categories, with mean risk matrix scores ranging from 2.7 for spatial structure to 3.3 for both abundance and growth rate/productivity) (Table B.3.2). All of the major risk factors identified by previous BRTs still remain. Most populations are at relatively low abundance, and those with adequate data for modeling are estimated to have a relatively high extinction probability. Some populations, particularly summer run, have shown higher returns in the last 2-3 years. The Willamette Lower Columbia River TRT (Myers et al. 2002) has estimated that at least four historical populations are now extinct. The hatchery contribution to natural spawning remains high in many populations.

Based on the provisional framework discussed in the general Introduction to this report, the BRT assumed as a working hypothesis that resident fish below historical barriers are part of this ESU, while those above long-standing natural barriers (e.g., in upper Clackamas, Sandy, and some of the small tributaries of the Columbia River Gorge) are not. Case 3 resident fish above dams on the Cowlitz, Lewis, and Sandy Rivers are of uncertain ESU status.

Upper Willamette River steelhead ESU

The majority (over 76%) of the BRT votes for this ESU fell in the "likely to become endangered" category, with small minorities falling in the "danger of extinction" and "not likely to become endangered" categories (Table B.3.1). The BRT did not identify any extreme risks for this ESU but found moderate risks in all the VSP categories (mean risk matrix scores ranged from 2.6 for diversity to 2.9 for both spatial structure and growth rate/productivity) (Table B.3.2). On a positive note, after a decade in which overall abundance (Willamette Falls count) hovered around the lowest levels on record, adult returns for 2001 and 2002 were up significantly, on par with levels seen in the 1980s. Still, the total abundance is small for an entire ESU, resulting in a number of populations that are each at relatively low abundance. The recent increases are encouraging but it is uncertain whether they can be sustained. The BRT considered it a positive sign that releases of the "early" winter-run hatchery population have been discontinued, but remained concerned that releases of non-native summer-run steelhead continue.

Because coastal cutthroat trout is a dominant species in the basin, resident *O. mykiss* are not as widespread here as in areas east of the Cascades. Resident fish below barriers are found in the Pudding/Molalla, Lower Santiam, Calapooia, and Tualatin drainages, and these would be considered part of the steelhead ESU based on the provisional framework discussed in the general Introduction. Resident fish above Big Cliff and Detroit Dams on the North Fork Santiam and above Green Peter Dam on the South Fork Santiam are of uncertain ESU affinity. Although no obvious physical barrier separates populations upstream of the Calapooia from those lower in the basin, resident *O. mykiss* in these upper reaches of the Willamette basin are quite distinctive both phenotypically and genetically and are not considered part of the steelhead ESU.

Northern California steelhead ESU

The majority (74%) of BRT votes were for "likely to become endangered," with the remaining votes split about equally between "in danger of extinction" and "not warranted" (Table B.3.1). Abundance and productivity were of some concern (scores of 3.7; 3.3 in the risk matrix); spatial structure and diversity were of lower concern (scores of 2.2; 2.5); although at least one BRT member gave scores as high as 4 for each of these risk metrics (Table B.3.2).

The BRT considered the lack of data for this ESU to be a source of risk due to uncertainty. The lack of recent data is particularly acute for winter runs. While there are older data for several of the larger river systems that imply run sizes became much reduced since the early twentieth century, there are no recent data suggesting much of an improvement.

Based on the provisional framework discussed in the general Introduction to this report, the BRT assumed as a working hypothesis that resident fish below historical barriers are part of the Northern California Coast Steelhead ESU, while those above long-standing natural barriers are not. Historically, resident fish are believed to have occurred in all areas in the ESU used by steelhead, although current distribution is more restricted. Resident fish above recent (usually man-made) barriers--including Robert W. Matthews Dam on the Mad River and Scott Dam on the Eel River--but below natural barriers are of uncertain ESU affinity. In this ESU, the inclusion of resident fish would not greatly increase the total numbers of fish, and the resident fish have not been exposed to large amounts of hatchery stocking.

Central California Coast steelhead ESU

The majority (69%) of BRT votes were for "likely to become endangered," and another 25% were for "in danger of extinction" (Table B.3.1). Abundance and productivity were of relatively high concern (mean score of 3.9 for each, with a range of 3 to 5 for each), and spatial structure was also of concern (score 3.6) (Table B.3.2). Predation by pinnipeds at river mouths and during the ocean phase was noted as a recent development posing significant risk.

There were no time-series data for this ESU. A variety of evidence suggested the largest run in the ESU (the Russian River winter steelhead run) has been reduced in size and continues to be reduced in size. Concern was also expressed about the populations in the southern part of the range of the ESU--notably populations in Santa Cruz County and the South Bay area.

Based on the provisional framework discussed in the general Introduction to this report, the BRT assumed as a working hypothesis that resident fish below historical barriers are part of the Central California Coast Steelhead ESU, while those above long-standing natural barriers are not. Historically, resident fish are believed to have occurred in all areas in the ESU used by steelhead, although current distribution is more restricted. Resident fish above recent (usually man-made) barriers--including Warm Springs Dam on Dry Creek, Russian River; Coyote Dam on the East Fork Russian River; Seeger Dam on Lagunitas Creek; Peters Dam on Nicasio Creek, Lagunitas Creek; and Standish Dam on Coyote Creek--but below natural barriers are of uncertain ESU affinity. In this ESU, an estimated 22% of historical habitat is behind recent barriers. The only relevant biological information about the populations above these barriers pertains to Alameda Creek, and suggests that some but not all populations above Dam 1 are genetically similar to populations within the ESU. For some BRT members, the presence of resident fish mitigated the assessment of extinction risk for the ESU as a whole.

South-Central California Coast steelhead ESU

The majority (68%) of BRT votes were for "likely to become endangered," and another 25% were for "in danger of extinction" (Table B.3.1). The strongest concern was for spatial structure (score 3.9; range 3-5), but abundance and productivity were also a concern (Table B.3.2). The cessation of plants to the ESU from the Big Creek Hatchery (Central Coast ESU) was noted as a positive development, whereas continued predation from sport fishers was considered a negative development.

New data suggests that populations of steelhead exist in most of the streams within the geographic boundaries of the ESU; however, the BRT was concerned that the two largest river systems—the Pajaro and Salinas basins—are much degraded and have steelhead runs much reduced in size. Concern was also expressed about the fact that these two large systems are ecologically distinct from the populations in the Big Sur area and San Luis Obispo County, and thus their degradation affects spatial structure and diversity of the ESU. Much discussion centered on the dataset from the Carmel River, including the effects of the drought in the 1980s, the current dependence of the population on intensive management of the river system, and the vulnerability of the population to future droughts.

Based on the provisional framework discussed in the general Introduction to this report, the BRT assumed as a working hypothesis that resident fish below historical barriers are part of the South-Central California Coast Steelhead ESU, while those above long-standing natural barriers are not. Historically, resident fish are believed to have occurred in all areas in the ESU used by steelhead, although current distribution is more restricted. Resident fish above recent (usually man-made) barriers--including San Antonia, Nacimiento, and Salinas dams on the Salinas River; Los Padres Dam on the Carmel River; Whale Rock Dam on Old Creek; and Lopez Dam on Arroyo Grande Creek--but below natural barriers are of uncertain ESU affinity. In this ESU, little of the historical habitat is behind recent barriers and most of that on the Salinas River. For some BRT members, the presence of resident fish mitigated the assessment of extinction risk for the ESU as a whole.

Southern California steelhead ESU

The majority (81%) of BRT votes were for "in danger of extinction," with the remaining 19% of votes being for "likely to become endangered" (Table B.3.1). Extremely strong concern was expressed for abundance, productivity, and spatial structure (mean scores of 4.8, 4.3, and 4.8, respectively, in the risk matrix), and diversity was also of concern (mean score of 3.6) (Table B.3.2).

The BRT expressed concern about the lack of data on this ESU, about uncertainty as to the metapopulation dynamics in the southern part of the range of the ESU, and about the fish's nearly complete extirpation from the southern part of the range. Several members were concerned and uncertain about the relationship between the population in Sespe Canyon, which is supposedly a sizeable population, and the small run size passing through the Santa Clara River, which connects the Sespe to the ocean. There was some skepticism that flows in the Santa Maria River were sufficient to allow fish passage from the ocean to the Sisquoc River, another "stronghold" of *O. mykiss* in the ESU.

Based on the provisional framework discussed in the general Introduction to this report, the BRT assumed as a working hypothesis that resident fish below historical barriers are part of the South California Steelhead ESU, while those above long-standing natural barriers are not. Historically, resident fish are believed to have occurred in all areas in the ESU used by steelhead, although current distribution is more restricted. Resident fish above recent (usually man-made) barriers--including Twitchell Dam on the Cuyama River; Bradbury Dam on the Santa Ynez River; Casitas Dam on Coyote Creek, Ventura River; Matilija Dam on Matilija Creek, Ventura River; Santa Felicia Dam on Piru Creek, Santa Clara River; and Casitac Dam on Casitac Creek, Santa Clara River--but below natural barriers are of uncertain ESU affinity. In this ESU, a large portion of the original area is behind barriers, and the few density estimates that are available from this ESU indicate that the inclusion of area above recent barriers would substantially increase the number of fish in the ESU. Due to the extremely low numbers of anadromous fish in this ESU, it is possible that above-barrier populations contribute a significant number of fish to the below-barrier population by spill over. For some BRT members, the presence of resident fish mitigated the assessment of extinction risk for the ESU as a whole.

California Central Valley steelhead ESU

The majority (66%) of BRT votes were for "in danger of extinction", and the remainder was for "likely to become endangered" (Table B.3.1). Abundance, productivity and spatial structure were of highest concern (4.2-4.4), although diversity considerations were of significant concern (3.6) (Table B.3.2). All categories received a 5 from at least one BRT member.

The BRT was highly concerned by the fact that what little new information was available indicated that the monotonic decline in total abundance and in the proportion of wild fish in the ESU was continuing. Other major concerns included the loss of the vast majority of historical spawning areas above impassable dams, the lack of any steelhead-specific status monitoring, and the significant production of out-of-ESU steelhead by the Nimbus and Mokelumne River fish hatcheries. The BRT viewed the anadromous life-history form as a critical component of diversity within the ESU and did not place much importance on sparse information suggesting widespread and abundant *O. mykiss* populations in areas above impassable dams. Dams both reduce the scope for expression of the anadromous life-history form, thereby greatly reducing the abundance of anadromous *O. mykiss*, and prevent exchange of migrants among resident populations, a process presumably mediated by anadromous fish.

Based on the provisional framework discussed in the general Introduction to this report, the BRT assumed as a working hypothesis that resident fish below historical barriers are part of the California Central Valley Steelhead ESU, while those above long-standing natural barriers are not. Historically, resident fish are believed to have occurred in all areas in the ESU used by steelhead, although current distribution is more restricted. Resident fish above recent (usually man-made) barriers--including Shasta Dam on the Upper Sacramento River; Whiskeytown Dam on Clear Creek; Black Butte Dam on Stony Creek; Oroville Dam on the Feather River; Englebright Dam on the Yuba River; Camp Far West Dam on the Bear River; Nimbus Dam on the American River; Commanche Dam on the Mokelumne River; New Hogan Dam on the Calaveras River; Goodwin Dam on the Stanislaus River; La Grange Dam on the Tuolumne River; and Crocker Diversion Dam on the Merced River--but below natural barriers are of uncertain ESU affinity. As noted above, collectively these dams have isolated a large fraction of historical steelhead habitat, and resident fish above the dams may outnumber ESU fish from below the dams.

Table B.3.1. Tally of FEMAT vote distribution regarding the status of 10 steelhead ESUs reviewed. Each of 16 BRT members allocated 10 points among the three status categories.

ESU	Danger of Extinction	Likely to Become Endangered	Not Likely to Become Endangered
Snake River[1]	14	103	23
Upper Columbia[1]	75	62	3
Middle Columbia[1]	1	71	68
Lower Columbia[2]	10	110	30
Upper Willamette[2]	7	106	37
Northern California	18	119	23
Central California Coast	40	111	9
South Central California	40	109	11
Southern California	129	31	0
Central Valley	106	54	0

[1] Votes tallied for 14 BRT members
[2] Votes tallied for 15 BRT members

Table B.3.2. Summary of risk scores (1 = low to 5 = high) for four VSP categories (see section "Factors Considered in Status Assessments" for a description of the risk categories) for the 10 steelhead ESUs reviewed. Data presented are means (range).

ESU	Abundance	Growth Rate/Productivity	Spatial Structure and Connectivity	Diversity
Snake River	3.1 (2-4)	3.2 (2-4)	2.5 (1-4)	3.1 (2-4)
Upper Columbia	3.5 (2-4)	4.3 (3-5)	3.1 (2-4)	3.6 (2-5)
Middle Columbia	2.7 (2-4)	2.6 (2-3)	2.6 (2-4)	2.5 (2-4)
Lower Columbia	3.3 (2-5)	3.3 (3-4)	2.7 (2-4)	3.0 (2-4)
Upper Willamette	2.8 (2-4)	2.9 (2-4)	2.9 (2-4)	2.6 (2-3)
Northern California	3.7 (3-5)	3.3 (2-4)	2.2 (1-4)	2.5 (1-4)
Central California Coast	3.9 (3-5)	3.9 (3-5)	3.6 (2-5)	2.8 (2-4)
South Central California	3.7 (2-5)	3.3 (2-4)	3.9 (3-5)	2.9 (2-4)
Southern California	4.8 (4-5)	4.3 (3-5)	4.8 (4-5)	3.6 (2-5)
Central Valley	4.4 (4-5)	4.3 (4-3)	4.2 (2-5)	3.6 (2-5)

B.4 REFERENCES

Adams, P. 2000. Memorandum to Rodney McInnis: Status review update for the steelhead northern California Evolutionarily Significant Unit. U.S. Dep. Commer., National Marine Fisheries Service, Southwest Fisheries Science Center, Santa Cruz/Tiburon Laboratory, Tiburon, California.

AFS (American Fisheries Society). 1991. Minutes of southern California steelhead meeting, US Fish and Wildlife Service Office, Ventura, California, January 22, 1991. Am. Fish. Soc., California-Nevada Chapter, Environmental Concerns Committee, 9 p. (Available from Trout Unlimited of California, 2530 San Pablo Ave., Suite D, Berkeley, CA 94702).

Alley, D. W., and Associates. 1994. Comparison of juvenile steelhead densities in 1981 and 1994 with estimates of total numbers of mainstem juveniles and expected numbers of adults returning to the San Lorenzo River, Soquel Creek and Corralitos Creek, Santa Cruz County, California. City of Santa Cruz Water Department, City of Watsonville Water Department Lompico County Water District San Lorenzo Valley Water District and Soquel Creek Water District. Project # 122-01, 123-01, 124-01, 125-01, Brookdale, California .

Alley, D. W., and Associates. 1995. Comparison of juvenile steelhead densities in 1981, 1994 and 1995 with an estimate of juvenile population size in the mainstem San Lorenzo River, with expected numbers of adults returning form juveniles reared in the mainstem river, Santa Cruz County, California. City of Santa Cruz Water Department, San Lorenzo Valley Water District and Lompico County Water District. Project # 135-01, 136-01. Brookdale, California.

Alley, D. W., and Associates. 1997. Comparison of juvenile steelhead densities in 1981 and 1994-96 in the San Lorenzo River and tributaries, with an estimate of juvenile population size in the mainstem river and expected adult returns from that production, Santa Cruz County, California. City of Santa Cruz Water Department and the San Lorenzo Valley Water District. Project # 143-01, 144-01. Brookdale, California.

Alley, D. W., and Associates. 1998. Comparison of juvenile steelhead densities in 1981 and 1994-97 in the San Lorenzo River and tributaries, Santa Cruz County, California; with an estimate of juvenile population size in the mainstem river and expected adult returns. City of Santa Cruz Water Department, and San Lorenzo Valley Water District. Project # 150-01. Brookdale, California .

Alley, D. W., and Associates. 1999. Comparisons of juvenile steelhead densities, population estimates and habitat conditions for the San Lorenzo River, Santa Cruz County, California, 1994-98; with predicted adult returns. City of Santa Cruz Water Department, Santa Cruz County Environmental Planning and the San Lorenzo Valley Water District. Project #150-02. Brookdale, California.

Alley, D. W., and Associates. 2000. Comparisons of juvenile steelhead densities, population estimates and habitat conditions for the San Lorenzo River, Santa Cruz County, California, 1995-99; with an index of adult returns. City of Santa Cruz Water Department, Santa Cruz County Environmental Planning and the San Lorenzo Valley Water District. Project #150-03. Brookdale, California.

Alley, D. W., and Associates. 2002. Comparison of juvenile steelhead densities in 1997 through 2001, in the San Lorenzo River and tributaries, Santa Cruz County, California; with an estimate of juvenile population size and an index of adult returns. City of Santa Cruz Water Department, San Lorenzo Valley Water District and NMFS. Project # 150-06. Brookdale, California .

Alley, D. W., and Associates. 2002. Comparison of juvenile steelhead densities in 1997 through 2001, in the San Lorenzo River and tributaries, Santa Cruz County, California; with an estimate of juvenile population size and an index of adult returns. City of Santa Cruz Water Department, San Lorenzo Valley Water District and NMFS. Draft report Project # 150-06. Brookdale, California .Anonymous. 1994. Oregon salmon and steelhead catch data, 1981-93. Unpublished.

Anonymous. 1995. 1995 Stock status review for winter steelhead, Mid-Willamette district, NW region.

Anonymous. 1997. ODFW Mid-Willamette Fish District unpublished files: winter steelhead Foster dam counts, Minto trap counts and run size estimates; Molalla R. spring chinook run size estimates through 1997.

Anonymous. 1998. Portland General Electric fish facility reports. Unpublished StreamNet Reference.

Anonymous. 1998. ODFW Columbia River Management unpublished files: Willamette Falls fish passage 1946-97.

Barnhart, R. A. 1986. Species profiles: Life histories and environmental requirements of coastal fishes and invertebrates (Pacific Southwest)--steelhead. U.S. Fish Wildl. Serv. Biol. Rep. 82(11.60), 21 p.

Behnke, R. J. 1992. Native trout of western North America. Am. Fish. Soc. Monog. 6, 275 p. American Fisheries Society, Bethesda, MD.

Berg, L (ed.). 2001. Yakima Subbasin Summary (Draft). Northwest Power Planning Council, Portland, OR.

Berry, R. L. 1978. Salmon and steelhead sport catch statistics, 1978. Unpublished.

Bjornn, T. C. 1978. Survival, production, and yield of trout and chinook salmon in the Lemhi River, Idaho. Univ. Idaho, Coll. For., Wildl. Range Sci. Bull. 27, 57 p.

Boughton, D. A. and H. Fish. MS. The current regional distribution of steelhead (*Oncorhynchus mykiss*) in Southern California. Available from NOAA Fisheries, Southwest Science Center, 110 Shaffer Road, Santa Cruz, CA.

Brown, L. R. and P. B. Moyle. 1981. The impact of squawfish on salmonid populations: a review. N. Amer. J. Fish. Man. 1: 104 – 111.

Brown, L. R. and P. B. Moyle. 1997. Invading species in the Eel River, California: successes, failures, and relationships with resident species. Environmental Biology of Fishes 49: 271 – 291.

Bryson, D. 2001. Draft Imnaha Subbasin Summary. Prepared for the Northwest Power Planning Council. 241 p.

Burgner, R. L., J. T. Light, L. Margolis, T. Okazaki, A. Tautz, and S. Ito. 1992. Distribution and origins of steelhead trout (*Oncorhynchus mykiss*) in offshore waters of the North Pacific Ocean. Int. North Pac. Fish. Comm. Bull. 51, 92 p.

Busby, P. J., O. W. Johnson, T. C. Wainwright, F. W. Waknitz, and R. S. Waples. 1993. Status review for Oregon s Illinois River winter steelhead. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-NWFSC-10, 85 p.

Busby, P. J., T. C. Wainwright, G. J. Bryant, L. Lierheimer, R. S. Waples, F. W. Waknitz, and I. V. Lagomarsino. 1996. Status review of west coast steelhead from Washington, Idaho, Oregon, and California. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-NWFSC-27, 261p.

CACSS (California Advisory Committee on Salmon and Steelhead). 1988. Restoring the balance. Calif. Dep. Fish Game, Sacramento, CA. 84 p.

Cardenas, M. 1996. Upper Sisquoc River survey. CDFG Report.

CDFG (California Department of Fish and Game). 1965. California fish and wildlife plan. Volume III supporting data: part B, inventory salmon-steelhead and marine resources. California Department of Fish and Game, Sacramento, California.679 p.

CDFG (California Department of Fish and Game). 1979. Nelson Creek wild trout management plan. California Department of Fish and Game, Sacramento, CA, 27 p.

CDFG (California Department of Fish and Game). 1982. 1982 status report of California wild and scenic rivers salmon and steelhead fisheries. Calif. Dept. Fish Game, Sacramento, CA, 159 p.

CDFG (California Department of Fish and Game). 1995. Letter to M. Schiewe for the ESA Administrative Record for west coast steelhead, dated 30 March 1995, 10 p. plus attachments. (Avail. from Environmental and Technical Services Division, Natl. Mar. Fish. Serv., 525 N.E. Oregon Street, Suite 500, Portland, OR 97232.)

CDFG (California Department of Fish and Game). 2000. Fishery management and evaluation plan, south-central California coast evolutionarily significant unit, steelhead, draft document. CDFG, Fisheries Programs Branch, 1416 Ninth Street, Sacramento, CA.

CDFG (California Department of Fish and Game). 2000. Fishery management plan for the Upper Sacramento River (Box Canyon Dam to Lake Shasta) 2000 to 2005. California Department of Fish and Game, Sacramento, CA, 52 p.

CDFG (California Department of Fish and Game). 2001. Fishery management plan, Central Valley, California Evolutionary Significant Unit, Steelhead. California Department of Fish and Game, Sacramento, CA, 59 p.

CDFG (California Department of Fish and Game). 2001a. Fishery management and evaluation plan, Central California Coast Evolutionarily Significant Unit, draft.

CDFG (California Department of Fish and Game). 2001b. Fishery management and evaluation plan, South-Central California Coast Evolutionarily Significant Unit, draft.

CDFG (California Department of Fish and Game). 2002. 2002 Freshwater sportfishing regulations booklet. Available from CDFG, 1416 Ninth Street, Room 1320, Sacramento, CA 95814. 70 pp.

CDFG (California Department of Fish and Game). 2003. Letter from D. Marston (CDFG) to M. Martinez (NMFS), dated January 9, 2003.

Chilcote, M. W. 1998. Conservation Status of Steelhead in Oregon. Information Report 98-3. Oregon Department of Fish and Wildlife.

Chilcote, M. W. 2001. Conservation Assessment of Steelhead Populations in Oregon. Oregon Department of Fish and Wildlife. Portland, OR.

Chilcote, M. W. 2002. Spreadsheet with 2002 Oregon steelhead escapement updates.

Cichosz, T., D. Saul, A. Davidson, W. Warren, D. Rollins, J. Willey, T. Tate, T. Papanicolaou and S. Juul. 2001. Clearwater Subbasin Summary. Draft submitted to the Northwest Power Planning Council. Nov. 2001. 477 p.

Clanton, D. A. and J. F. Jarvis. 1946. Memorandum to Bureau of Fish Conservation re: field inspection trip to the Matilija-Ventura watershed in relation to the construction of the proposed Matilija Dam, dated 8 May 1946. Calif. Dep. Nat. Resources., Div. Fish Game, 3 p. (Available from Environmental and Technical Services Division, Natl. Mar. Fish. Serv., 525 N.E. Oregon Street, Suite 500, Portland, OR 97232.).

Comstock, R. 1992. Santa Clara River steelhead restoration assessment. US Fish and Wildlife Service, Western Washington Fishery Resource Office, Olympia, Washington, 10 pp. (Available from Environmental and Technical Services Division, Natl. Mar. Fish. Serv., 525 N.E. Oregon Street, Suite 500, Portland, OR 97232.).

Cooney, T. 2001. Upper Columbia River steelhead and spring chinook salmon quantitative analysis report. Part 1: run reconstructions and preliminary analysis of extinction risks. National Marine Fisheries Service. Hydro Program. Technical Review Draft

Cramer, D. 2002a. Portland General Electric - Clackamas winter steelhead adults. Portland General Electric. Data delivered via e-mail from Kathryn Kostow, Oregon Dept of Fish and Wildlife.

Cramer, D. 2002b. Portland General Electric - sandy winter steelhead adults. Portland General Electric. Data delivered via e-mail from Kathryn Kostow, Oregon Dept of Fish and Wildlife.

Cramer, S. P., and 12 co-authors. 1995. The status of steelhead populations in California in regards to the Endangered Species Act. Document prepared for Association of California Water Agencies, 167 p. (Available from Environmental and Technical Services Division, Natl. Mar. Fish. Serv., 525 N.E. Oregon Street, Suite 500, Portland, OR 97232.).

Cramer, S., R. Beamesderfer, P. Monk, K. Witty, A. Kalin, B. Lister & C. Akerman. 2002. Mid-Columbia steelhead trout population viability assessment. S.P. Cramer & Assoc. Progress Rept. Submitted to NMFS. April 2002.

CRFMP TAC (Columbia River Fisheries Management Plan Technical Advisory Committee). 1991. Summer steelhead. In Columbia River fish management plan: 1991 All species review. Technical Advisory Committee, U.S. v. Oregon. (Available from Environmental and Technical Services Division, Natl. Mar. Fish. Serv., 525 N.E. Oregon Street, Suite 500, Portland, OR 97232.)

Currens, K. P., S. L. Stone, and C. B. Schreck. 1987. A genetic comparison of rainbow trout (*Salmo gairdneri*) above and below Izee Falls in the John Day River, Oregon. Oregon Coop. Fish. Res. Unit Genet. Lab. Rep. 87(2), 34 p.

Currens, K. P., C. B. Schreck, and H. W. Li. 1990. Allozyme and morphological divergence of rainbow trout (*Oncorhynchus mykiss*) above and below waterfalls in the Deschutes River, Oregon. Copeia 1990:730-746.

Deinstadt, J. M., and Berry, M. A. 1999. California wild trout program, Hat Creek wild trout management plan, 1998 - 2003. California Department of Fish and Game, Sacramento, CA, 51 p.

Engblom, S. 1997. Compilation report for the 1996-97 Santa Ynez River Memorandum of understanding. SYRTAC.

Engblom, S. 1999. Compilation report for the 1998-99 Santa Ynez River Memorandum of understanding.

Engblom, S. 2001. 2001 Lower Santa Ynez River steelhead studies – annual report, Santa Barbara County, California.

Entrix. 1995. Historical steelhead run in the Santa Ynez River. Project No. 374100, prepared for Price Postel and Parma, 200 E. Carillo St., Santa Barbara, CA 93102.

Everest, F. H. 1973. Ecology and management of summer steelhead in the Rogue River. Oregon State Game Commission, Fishery Research Report 7, Corvallis, 48 p.

Foerster, R. E. 1947. Experiment to develop sea-run from land-locked sockeye salmon *(Oncorhynchus nerka kennerlyi*). J. Fish. Res. Board Can. 7(2):88-93.

Fulton, L. A., and R. E. Pearson. 1981. Transplantation and homing experiments on salmon, *Oncorhynchus* spp., and steelhead trout, *Salmo gairdneri*, in the Columbia River system: fish of the 1939-1944 broods. U.S. Dep. Commer., NOAA Tech. Memo. NMFS F/NWC 12, 97 p.

Gephart, L. & D. Nordheim (eds) 2001. Tucannon Subbasin Summary. Prepared for the Northwest Power Planning Council. 222 pages.

Gorman, L. 2001. Hood steelhead at Powerdale dam. StreamNet Excel workbook provided to Paul McElhany from Leah Gorman 10/16/2001. This workbook is based on data provided by Rod French to ODFW/NMFS in the Microsoft Word file Data2000.doc on 7/31/2001.

Grass, A. 1995. Annual Report: Van Arsdale Fisheries Station, 1993-94. California Department of Fish and Game, Inland Fisheries. Administrative Report Number 95-5, 10p.

Griswold, K. E. 1996. Genetic and meristic relationships of coastal cutthroat trout (*Oncorhynchus clarki clarki*) residing above and below barriers in two coastal basins. M.S. Thesis, Oregon State Univ., Corvallis, OR, 83 p.

Hannon, J. and M. Healey. 2002. American River Steelhead Redd Surveys, 2001-2002. U. S. Bureau of Reclamation and California Department of Fish and Game. 19 p.

Hanson, C. H., J. Hagar, S. Englom, and B. Bemis. 1996. Synthesis and analysis of information collected on the fishery resources and habitat conditions of the lower Santa Ynez River: 1993 – 1996.

Harvey, B. C., J. L. White and R. J. Nakamoto. 2002. Habitat relationships and larval drift of native and nonindigenous fishes in neighboring tributaries of a coastal California river. Trans. Amer. Fish. Soc. 131: 159 – 170.

Henke, E. 1994. Letters to G. Bryant re: information on steelhead for the Administrative Record for west coast steelhead. (Available from Environmental and Technical Services Division, Natl. Mar. Fish. Serv., 525 N.E. Oregon Street, Suite 500, Portland, OR 97232.)

Hulett et al. 1995. Studies of hatchery and wild steelhead in the lower Columbia basin. Washington Department of Fish and Wildlife. Report #RAD 95-3.

Hunt, W. 1999. Calapooia River St W Spawning Surveys, Winter Steelhead Counts Upper Willamette River, Late-Run Winter Steelhead Run Size Estimates and St W Returns to Minto Trap. ODFW.

Hunt, L. E., P. E. Lehman, and M. H. Capelli. 1992. Vertebrate resources at Emma Wood State Park and the Ventura River estuary, Ventura County, California: Inventory and management. Calif. Dep. Parks Rec., document dated 6 November 1992, 107 p. (Available from Environmental and Technical Services Division, Natl. Mar. Fish. Serv., 525 N.E. Oregon Street, Suite 500, Portland, OR 97232.)

IEP (Interagency Ecological Program Steelhead Project Workteam). 1998. Monitoring, assessment, and research on Central Valley steelhead: status of knowledge, review of existing programs, and assessment of needs. Available online at: http://calfed.ca.gov/programs/cmarp/a7a11.html

IDFG (Idaho Department of Fish and Game). 1994. Documents submitted to the ESA Administrative Record for west coast steelhead by E. Leitzinger, 18 October 1994. (Available from Environmental and Technical Services Division, Natl. Mar. Fish. Serv., 525 N.E. Oregon Street, Suite 500, Portland, OR 97232.).

IDFG (Idaho Department of Fish and Game). 2002. Written comments submitted to National Marine Fisheries Service regarding status review.

James, G. and C. Scheeler. 2001. Walla Walla Subbasin Summary (Draft). Northwest Power Planning Council, Portland, OR.

Johnson, T. H. and R. Cooper. 1995. Anadromous game fish research and planning, July 1 1993-December 31, 1994. Washington Dept of Fish and Wildlife. Streamnet.org Reference.

Johnson, O. W., M. H. Ruckelshaus, W. S. Grant, F. W. Waknitz, A. M. Garrett, G. J. Bryant, K. Neely, and J. J. Hard. 1999. Status review of coastal cutthroat trout from Washington, Oregon, and California. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-37, 292 p.

Jonsson, B. 1985. Life history patterns of freshwater resident and sea-run migrant brown trout in Norway. Trans. Am. Fish. Soc. 114:182-194.

Kaeriyama, M., S. Urawa, and T. Suzuki. 1992. Anadromous sockeye salmon (*Oncorhynchus nerka*) derived from nonanadromous kokanees: Life history in Lake Toro. Sci. Rep. Hokkaido Salmon Hatchery 46:157-174.

Kennedy, T. 2002. Stanislaus River anadromous fish surveys 2000-2001. Report from Fisheries Foundation to A. Hamilton, USFWS, Sacramento, CA.

Kesner, W. D., and R. A. Barnhart. 1972. Characteristics of the fall-run steelhead trout (*Salmo gairdneri gairdneri*) of the Klamath River system with emphasis on the half-pounder. California Fish and Game 58(3):204-220.

Kier & Associates. 2001. Battle Creek salmon and steelhead restoration project. Draft Adaptive Management Plan. Sausalito, CA. 79 p.

Killam, D. 2002. Field notes for Thomes Creek 2002. California Department of Fish and Game, Red Bluff CA.

Kostow, K. 2002. Leaburg and McKenzie abundance. Data delivered via e-mail, September 2002.

Kostow, K. 2003. The biological implications of non-anadromous *Oncorhynchus mykiss* in Columbia basin steelhead ESUs. Report to NOAA Fisheries & ODFW. Draft report to NMFS. Jan. 13, 2003. 90 p.

Mallet, J. 1974. Inventory of salmon and steelhead resources, habitats, use and demands. Job Performance Report. Proj. F-58-R-1. Idaho Dept. of Fish and Game. Boise. Idaho.

Maslin, P. E., M. Lennox, and J. Kindopp. 1998. Intermittent streams as rearing habitat for Sacramento River chinook salmon (*Oncorhynchus tshawytscha*). CSU Chico unpublished report. 51 p.

McClure, M. M., E. E. Holmes, B. L. Sanderson & C. E. Jordan. In press. A large-scale multi-species assessment: Anadromous Salmonids in the Columbia River Basin. 45 p + figures and tables. Ecological Applications.

McElhany, P., M. H. Ruckelshaus, M. J. Ford, T. C. Wainwright, and E. P. Bjorkstedt. 2000. Viable salmonid populations and the recovery of evolutionarily significant units. U. S. Dept. Commer. NMFS-NWFSC-42.

McElhany, P., T. Backman, C. Busack, S. Heppell, S. Kolmes, A. Maule, J. Myers, D. Rawding, D. Shively, and C. Steward. 2002. Willamette/Lower Columbia Pacific salmonid viability criteria. Draft report from the Willamette/Lower Columbia Technical Recovery Team. December 2002.

McEwan, D. R. 2001. Central Valley steelhead. In R. L. Brown, editor, *Fish Bulletin 179*, pages 1-43. California Department of Fish and Game, Sacramento, CA.

McEwan, D. R. 2001. Steelhead rainbow trout. Pages 418-425 *in* W. S. Leet, C. M. Dewees, C. M Klingbeil, and E. J. Larson, editors. California's living marine resources: a status report. University of California, Agriculture and Natural Resources, Publication SG01-11.

McEwan, D. R. 2001. Central Valley steelhead. In R. L. Brown, editor, *Fish Bulletin 179*, pages 1-43. California Department of Fish and Game, Sacramento, CA.

McEwan, D., and T. A. Jackson. 1996. Steelhead restoration and management plan for California. California Dep. Fish Game, 234 p. (Available from California Department of Fish and Game, Inland Fisheries Division, 1416 Ninth Street, Sacramento, CA 95814.)

Meyer Resources. 1988. Benefits from present and future salmon and steelhead production in California. Report to the California Advisory Committee on Salmon and Steelhead, 78 p. (Available from California Advisory Committee on Salmon and Steelhead Trout, 120 Schoonmaker Point, Foot of Spring Street, Sausalito, CA 94965.)

Monterey Peninsula Water Management District (MPWMD). 2001. Executive summary, 2000-20001, MPWMD Mitigation Program and Water Allocation Program Environmental Impact Report.

Moore, M. R. 1980. An assessment of the impacts of the proposed improvements to the Vern Freeman Diversion on anadromous fishes of the Santa Clara River System, Ventura County, California.

Moore, T. L. 2001. Steelhead Survey Report for Antelope, Deer, Beegum and Mill Creeks, 2001. CDFG Sacramento River Salmon and Steelhead Assessment Program. California Department of Fish and Game. 8 p.

Mullan, J. W., K. R. Williams, G. Rhodus, T. W. Hillman, and J. D. McIntyre. 1992. Production and habitat of salmonids in mid-Columbia River tributary streams. Monograph I, U.S. Fish and Wildlife Service, Box 549, Leavenworth, WA 98826, 489 p.

Myers, J. M., C. Busack, D. Rawding, and A. Marshall. 2002. Identifying historical populations of chinook and chum salmon and steelhead within the lower Columbia River and upper Willamette River evolutionary significant units. Draft report to the co-managers from the Willamette/Lower Columbia River Technical Recovery Team (10 May 2002).

Nehlsen, W., J.E. Williams, and J. A. Lichatowich. 1991. Pacific salmon at the crossroads: stocks at risk from California, Oregon, Idaho, and Washington. Fisheries 16: 4 – 21.

Nielsen, J. L., E. A. Heine, C. A. Gan and M. C. Fountain. 2000. Molecular analysis of population genetic structure and recolonization of rainbow trout following the Cantara spill. California Fish and Game 88:21-40.

NMFS (National Marine Fisheries Service). 1991. Notice of policy: Policy on applying the definition of species under the Endangered Species Act to Pacific salmon. Federal Register [Docket 910248-1255, 20 November 1991] 56(224):58612-58618.

NMFS (National Marine Fisheries Service). 1993. Endangered and threatened species; Illinois River winter steelhead in Oregon. Federal Register [Docket 930517-3117, 20 May 1993] 58(96): 29390-29392.

NMFS (National Marine Fisheries Service). 1997. Status Review Update for West Coast Steelhead from Washington, Idaho, Oregon, and California. Memorandum from the Biological Review Team to the NMFS Northwest Regional Office. July 7, 1997, 72 p.

NMFS (National Marine Fisheries Service). 1998*a*. Status review update for deferred and candidate ESUs of west coast steelhead (Lower Columbia River, Upper Willamette River, Oregon Coast, Klamath Mountains Province, Northern California, Central Valley, and Middle Columbia River ESUs). Pre-decisional ESA document, National Marine Fisheries Service.

NMFS (National Marine Fisheries Service). 1998*b*. Status review update for deferred ESUs of west coast steelhead: hatchery populations (Lower Columbia River, Klamath Mountains Province, Northern California, and Central Valley). Predecisional ESA document, National Marine Fisheries Service.

NMFS (National Marine Fisheries Service). 1999. Updated Review of the Status of the Upper Willamette River and Middle Columbia River ESUs of Steelhead. Memorandum for W. Stelle and W. Hogarth from M. Schiewe. January 12, 1999, 49 p.

NMFS (National Marine Fisheries Service). 2002. Memorandum for Frank L. Cassidy, Jr. (Northwest Power Planning Council) from Bob Lohn (NMFS), April 2002. (Available at http://www.nwr.noaa.gov/occd/InterimTargets.pdf)

Nobriga, M. 1995. Cosumnes River study. California Department of Fish and Game, Rancho Cordova, CA. 10 p.

Nobriga, M. and P. Cadrett. 2001. Differences among hatchery and wild steelhead: evidence from Delta fish monitoring programs. IEP Newsletter 14: 30-38.

Nordeng, H. 1983. Solution to the "char problem" based on Arctic char (*Salvelinus alpinus*) in Norway. Can. J. Fish. Aquat. Sci. 40:1372-1387.

Nowak, M.C. 2001. Draft Grande Ronde Subbasin Summary. Prepared for the Northwest Power Planning Council. 385 pages.

ODFW (Oregon Department of Fish and Wildlife). 1990. Santiam and Calapooia Rivers: Willamette River subbasin : salmon and steelhead production plan. Oregon Department of Fish and Wildlife. Northwest Power Planning Council.

ODFW (Oregon Department of Fish and Wildlife). 1991. Grand Ronde River subbasin salmon and steelhead plan. Prepared for Northwest Power Planning Council. 129 pp.

ODFW (Oregon Department of Fish and Wildlife). 1999. Personal communications for reconstructed run year estimates from punch cards for steelhead, 1956-1970. Unpublished.

ONRC (Oregon Natural Resources Council), Siskiyou Regional Education Project, Federation of Fly Fishers, Kalmiopsis Audubon Society, Siskiyou Audubon Society, Klamath/Siskiyou Coalition, Headwaters, The Wilderness Society, North Coast Environmental Center, Oregon Chapter of The Sierra Club, and The National Wildlife Federation. 1992. Petition for a rule to list the Illinois River winter steelhead as threatened or endangered under the Endangered Species Act and to designate critical habitat. Unpubl. manuscr., 16 p. (Document submitted to USDOC NOAA NMFS Northwest Region, Seattle, Washington, May 1992).

Puckett, L. K. 1969. Fisheries surveys on Thomes and Stony Creeks, Glenn and Tehama Counties, with special emphasis on their potentials for King Salmon spawning. California Department of Fish and Game, Water Projects Branch Administrative Report No. 69-3. 24 p.

Rawding, D. 2002a. Lower Columbia River summer-run steelhead. Excel Workbook sent from Dan Rawding (WDFW) to Paul McElhany via e-mail to Paul McElhany and Sarah Sydor, NWFSC.

Rawding, D. 2001b. Simsam (Steelhead). Unpublished data and documentation sent from Dan Rawding (WDFW) to Paul McElhany on 5/16/2001 as Excel file and Word document, via e-mail.

Reavis, B. 1991. Status of California steelhead stocks. In Pacific States Marine Fisheries Commission and Association of Northwest Steelheaders (organizers), International Symposium on Steelhead Trout Management, January 3-5, 1991, Portland, OR, p. 57 – 63.

Reese, C. D. and B. C. Harvey. 2002. Temperature-dependent interactions between juvenile steelhead and Sacramento pikeminnow in laboratory streams. Trans. Am. Fish. Soc. 131: 599 – 606.

Reynolds, F. L., T. J. Mills, R. Benthin and A. Low. 1993. Restoring Central Valley streams: a plan for action. California Department of Fish and Game, Sacramento, CA, 184 p.

Robertson, S. R. 1985. Clavey River wild trout habitat management plan. Stanislaus National Forest, Sonora, CA, 14 p. (from CV steelhead; not in master list)

Rode, M., and Weidlein, W. D. 1986. California wild trout management program, Fall River management plan. California Department of Fish and Game, Inland Fisheries Admin. Rpt. 86-2. 55 p. (from CV steelhead; not in master list)

Roelofs, T. D. 1983. Current status of California summer steelhead (*Salmo gairdneri*) stocks and habitat, and recommendations for their management. Submitted to USDA Forest Service, Region 5, 77 p. (Available from Environmental and Technical Services Division, Natl. Mar. Fish. Serv., 525 N.E. Oregon Street, Suite 500, Portland, OR 97232.).

Ruiz-Campos, G. and E. P. Pister. 1995. Distribution, habitat, and current status of the San Pedro Martir rainbow trout, *Oncorhynchus mykiss nelsoni* (Evermann). Bulletin of the Southern California Academy of Sciences, 94(2): 131 – 148.

Schill, D. J. and R. L. Scarpella. 1997. Barbed hook restrictions in catch-and-release trout fisheries: a social issue. N. Am. J. Fish. Man. 17: 873 – 881.

Servheen, G. Draft Salmon Subbasin Summary. Prepared for the Northwest Power Planning Council. 481 p. + app.

Shapovalov, L. 1944. Preliminary report on the fisheries of the Santa Ynez River System, Santa Barbara County, California. CDFG Report, 22 pp.

Shapovalov, L. and A. C. Taft. 1954. The life histories of the steelhead rainbow trout (*Salmo gairdneri gairdneri*) and silver salmon (*Oncorhynchus kisutch*) with special reference to Waddell Creek, California, and recommendations regarding their management. Calif. Dep. Fish Game Fish Bull. 98, 375 pp.

Sharp, B. 2001. Klickitat Subbasin Summary. Northwest Power Planning Council, Portland, OR.

Shea, K., and M. Mangel. 2001. Detection of population trends in threatened coho salmon (*Oncorhynchus kisutch*). Can. J. Fish. Aquat. Sci. 58: 375-385.

Smith, J. J. 1994. Abundance of coho and steelhead in Redwood Creek in 1994. Department of Biological Sciences, San Jose State University. San Jose, CA.

Smith, J. J. 1992. Distribution and abundance of juvenile coho and steelhead in Waddell, Scott and Gazos Creeks in 1992. Department of Biological Sciences, San Jose State University. San Jose, California.

Smith, J. J. 1994. Distribution and abundance of juvenile coho and steelhead in Scott and Gazos Creeks in 1993. Department of Biological Sciences, San Jose State University. San Jose, CA.

Smith, J. J. 1994. Distribution and abundance of juvenile coho and steelhead in Scott and Waddell Creeks in 1988 and 1994: Implications for status of southern coho. Department of Biological Sciences, San Jose State University. San Jose, California.

Smith, J. J. 1995. Distribution and abundance of juvenile coho and steelhead in Waddell, Scott and Gazos Creeks in 1995. Department of Biological Sciences, San Jose State University. San Jose, California.

Smith, J. J. 1996. Distribution and abundance of coho and steelhead in Redwood Creek in November 1996. Department of Biological Sciences, San Jose State University. San Jose, California.

Smith, J. J. 1996. Distribution and abundance of juvenile coho and steelhead in Gazos, Waddell and Scott Creeks in 1995. Department of Biological Sciences, San Jose State University. San Jose, California.

Smith, J. J. 1996. Distribution and abundance of juvenile coho and steelhead in Gazos, Waddell and Scott Creeks in 1996. Department of Biological Sciences, San Jose State University. San Jose, California.

Smith, J. J. 1997. Distribution and abundance of coho and steelhead in Redwood Creek in fall 1997. Department of Biological Sciences, San Jose State University. San Jose, California.

Smith, J. J. 1998. Distribution and abundance of coho and steelhead in Redwood Creek in fall 1998. San Jose, California.

Smith, J. J. 1998. Distribution and abundance of juvenile coho and steelhead in Gazos, Waddell and Scott Creeks in 1997 and the implications for status of southern coho. Department of Biological Sciences, San Jose State University. San Jose, California.

Smith, J. J. 1998. Distribution and abundance of juvenile coho and steelhead in Gazos, Waddell and Scott Creeks in 1998. Department of Biological Sciences, San Jose State University. San Jose, California.

Smith, J. J. 1999. Distribution and abundance of juvenile coho and steelhead in Gazos, Waddell and Scott Creeks in 1999. Department of Biological Sciences, San Jose State University. San Jose, California.

Smith, J. J. 2000. Distribution and abundance of juvenile coho and steelhead in Gazos, Waddell and Scott Creeks in 2000. Department of Biological Sciences, San Jose State University. San Jose, California.

Smith, J. J. 2000. Distribution and abundance of juvenile coho and steelhead in Redwood Creek in fall 2000. San Jose, California.

Smith, J. J. 2001. Distribution and abundance of juvenile coho and steelhead in Gazos, Waddell and Scott Creeks in 2001. Department of Biological Sciences, San Jose State University. San Jose, California.

Smith, J. J. 2001. Distribution and abundance of juvenile coho and steelhead in Redwood Creek in fall 2001. Department of Biological Sciences, San Jose State University. San Jose, California.

Smith, J. J. 2002. Distribution and abundance of juvenile coho and steelhead in Redwood Creek in fall 2002. Department of Biological Sciences, San Jose State University. San Jose, California.

Snider, B., and R. G. Titus. 1998. Evaluation of juvenile anadromous salmonid emigration in the Sacramento River near Knights Landing; November 1995 - July 1996. California Department of Fish and Game, Stream Evaluation Program Technical report 98-5.

Snider, B., and R. G. Titus. 2000a. Timing, composition and abundance of juvenile anadromous salmonid emigration in the Sacramento River near Knights Landing; October 1996 - September 1997. California Department of Fish and Game, Native Anadromous Fish and Watershed Branch, Stream Evaluation Program Technical report 00-4.

Snider, B., and R. G. Titus. 2000b. Timing, composition and abundance of juvenile anadromous salmonid emigration in the Sacramento River near Knights Landing October 1997-September 1998. California Department of Fish and Game, Habitat Conservation Division, Native Anadromous Fish and Watershed Branch, Stream Evaluation Program Technical Report 00-5.

Snider, B., and R. G. Titus. 2000c. Timing, composition and abundance of juvenile anadromous salmonid emigration in the Sacramento River near Knights Landing; October 1998 - September 1999. California Department of Fish and Game, Native Anadromous Fish and Watershed Branch, Stream Evaluation Program Technical report 00-6.

Snider, W. M. 1983. Reconnaissance of the steelhead resource of the Carmel River drainage, Monterey County. Calif. Dep. Fish Game, Environmental Services Branch Admin. Rep. 83-3., 41 p. (Available from California Department of Fish and Game, Inland Fisheries Division, 1416 Ninth Street, Sacramento, CA 95814.)

Snyder, J. O. 1925. The half-pounder of Eel River, a steelhead trout. Calif. Fish Game 11(2): 49-55.

Stephens, S. J., Christenson, D. P., Lechner, M., and Werner, H. 1995. Upper Kern Basin fishery management plan. California Department of Fish and Game, Sacramento, CA, 86 p.

Stoecker, M.W. and CCP (Conception Coast Project). 2002. Steelhead assessment and recovery opportunities in Southern Santa Barbara County, California. Conception Coast Project, Santa Barbara.

Titus, R. G., D. C. Erman, and W. M. Snider. MS. History and status of steelhead in California coastal drainages south of San Francisco Bay.

Titus, R. G. and C. D. Vanicek. 1988. Comparative hooking mortality of lure-caught Lahontan cutthroat trout at Heenan Lake, California. Calif. Fish Game 74: 218 – 225.

USFWS (U.S. Fish and Wildlife Service). 2000. Anadromous fish restoration actions in the Butte Creek Watershed. Programmatic Environmental Assessment. Sacramento, CA.

Waples, R. S. 1998. Willamette Steelhead. Memorandum to Mike Delarm and Garth Griffin, NMFS Regional Office, Portland, 2 July 1998. 2 p.

WDF (Washington Department of Fisheries), Washington Department of Wildlife (WDW), and Western Washington Treaty Indian Tribes (WWTIT). 1992. 1992 Washington State salmon and steelhead stock inventory (SASSI). Wash. Dep. Fish Wildl., Olympia, 212 p. + 5 regional volumes. (Available from Washington Department of Fish and Wildlife, 600 Capitol Way N., Olympia, WA 98501-1091.)

WDFW ((Washington Department of Fisheries and Wildlife). 1997. "Preliminary stock status update for steelhead in the Lower Columbia River, Washington (WDFW Kalama Research)." Data via Michelle McClure; references from Eli Holmes.

Withler, R. E. 1988. Genetic consequences of fertilizing chinook salmon (*Oncorhynchus tshawytscha*) eggs with pooled milt. Aquaculture 68: 15-25.

Workman, M. L. 2001. Lower Mokelumne River upstream fish migration monitoring conducted at Woodbridge Irrigation District Dam, August 2000 through April 2001. East Bay Municipal Utility District, Lodi, CA. 21 p.

Yoshiyama, R. M., F. W. Fisher, and P. B. Moyle. 1998. Historical abundance and decline of chinook salmon in the Central Valley region of California. N. Am. J. Fish. Man. 18:487-521.

Zimmerman, C. E. and G. H. Reeves. 2000. Population structure of sympatric anadromous and nonanadromous *Oncorhynchus mykiss*: evidence from spawning surveys and otolith microchemistry. Can. J. Fish. Aquat. Sci. 57:2152-2162.

B.5 APPENDICES

Appendix B.5.1. Distribution of *O. mykiss* trout by category in the Columbia Basin steelhead ESUs. Only major barriers are noted; numerous small barriers, both natural and artificial, also exist. Many other natural barriers are present but have *O. clarki* trout, rather than *O. mykiss* trout, above them. *O. mykiss* trout distribution in areas of sympatry with steelhead may be restricted in some areas if native *O. clarki* trout are also in the basin. The generalized listing of basins and subbasins does not imply that these constitute single trout populations or that trout distribution is continuous throughout the areas listed. Detailed trout distribution is usually unknown and actual demographically independent trout populations have not been described. All current trout distributions are decreased from historical distributions. In particular many mainstem and lower basin tributary are no longer used but probably were historically. Many current trout populations are only in upper basins and are highly fragmented (from Kostow 2003).

ESU	**Category 1 Trout Populations (Sympatric)**	**Category 2 Trout Populations (Major Natural Barriers)**	**Category 3 Trout Populations (Major Artificial Barriers)**
Willamette River	Pudding/Molalla Lower Santiam Calapooia Tualatin (Gales Cr.)	All populations upstream of Calapooia McKenzie M. Fork Willamette	N. Fork Santiam (Big Cliff/Detroit dams) S. Fork Santiam (Green Peter Dam)
Lower Columbia River	Historic use of lower basins by trout may have been greater Wind Clackamas: Callowash Other areas (?) Hood: West Fork Middle Fork Sandy (?) Upper Cowlitz Upper Kalama Upper Lewis Upper Washougal	Clackamas: Roaring R. North Fork South Fork Memaloose (?) Sandy: Little Sandy Salmon (?) Some of the Columbia Gorge small tributaries	Cowlitz (Mayfield Dam) Lewis (Merwin Dam) Sandy (Bull Run dams)

Appendix B.5.1 (continued)

ESU	Category 1 Trout Populations (Sympatric)	Category 2 Trout Populations (Major Natural Barriers)	Category 3 Trout Populations (Major Artificial Barriers)
Middle Columbia River	Historically all areas where steelhead are/were present. Trout distributions currently more restricted. Fifteenmile Eightmile Deschutes Klickitat Umatilla: Upper Umatilla John Day: Upper tributaries Walla Walla Upper tributaries Yakima: Upper Yakima Naches Some other small tributaries	All natural barriers upstream of Klickitat and Deschutes Basins: Deschutes: White River Upper Deschutes (Big Falls) Upper N. Fork Crooked R. John Day: Upper S. Fork John Day	Trout distributions currently more restricted than historically Little White Salmon (Conduit Dam) Deschutes (Pelton/Round Butte dams) Metolius Squaw Cr. Crooked River Umatilla (Irrigation dams) Willow Cr. Butter Cr. McKay Cr.

Appendix B.5.1 (continued)

ESU	Category 1 Trout Populations (Sympatric)	Category 2 Trout Populations (Major Natural Barriers)	Category 3 Trout Populations (Major Artificial Barriers)
Snake River	Potentially all areas that are/were used by steelhead. Tucannon Asotin Grande Ronde Imnaha Salmon found in about 43% of streams Clearwater Selway Other areas?	Palouse River Malad River Several Hells Canyon tributaries Upper Malheur Basin "recent" disconnect from lower Malheur Lakes Basin	Trout distributions currently more restricted than historically North Fork Clearwater (Dworshak Dam) Mainstem Snake (Hells Canyon Dam) Powder Burnt Malheur Owhyee Weiser Payette Boise Burneau Salmon Falls Cr. Several small tributaries
Upper Columbia River	Potentially all areas that are/were used by steelhead Wenatchee Lower Entiat Methow Okanogan	Upper Entiat Upper Kootenay Okanogan: Enlow Falls? Methow: Chewuch? Lost	Trout distributions currently more restricted than historically Okanogan Basin: Conconully Dam/Enlow Dam? Chief Joseph Dam Lower Spokane to Post Falls Sanpoil Several small tributaries Lower Pend Oreille to Z-Canyon Columbia headwaters in Canada

Appendix B.5.2. Distribution, abundance, and stocking of *Oncorhynchus mykiss* above major recent barriers (Case 3 situations) within 5 steelhead ESUs in California, listed by ESU and watershed. A major barrier blocks or restricts access to ≥ 100 square miles of a watershed. Names of keystone (lowermost complete) barriers are shown in bold, partial or seasonal barriers shown in italics. SH=steelhead, RT=rainbow trout (usually means resident),?=unknown. Blanks indicate no data. See text for details.

ESU / Basin / Subbasin			**---- Stream Length ----**			***O. mykiss* above barrier**								
	Dam Name	**Year Built**	**Total (km)**	**Above Barrier (km)**	**Above Barrier (%)**	**present**	**distribution**	**abundance**	**Density (no./km)**	**stocked**	**most recent**	**source hatchery**	**stocking notes**	**source**
Northern California														
Mad River			1,188											
Mad River	**Robert W Matthews**	1962		282	24%	yes		low; gets warm in summer		yes	ongoing	various	18,000 / year	4
Eel River			8,654											
Eel River	*Van Arsdale*	1907		1,106	13%	SH, RT								
	Scott	1921		963	11%	yes								17, 5
Sfk Eel River	*Benbow*	1932		949	11%	SH								
	ESU Total		15,496	1,245	8%									
Central California Coast														
Russian River			3,129											
Russian River	*Russian Rv No 1*	1963		2,878	92%									
	Healdsburg Rec	1953		2,591	83%									
Dry Creek	**Warm Springs**	1982		271	9%	yes	all tribs			yes		private, Warm Springs	~1984-87, Russian River steelhead from Warm Springs Hatchery released above WS Dam	6
E Fk Russian River	**Coyote Valley**	1959		269	9%	yes				yes				
Lagunitas Creek			202											

ESU / Basin / Subbasin	Dam Name	Year Built	---- Stream Length ---- Total (km)	Above Barrier (km)	Above Barrier (%)	*O. mykiss* above barrier present	distribution	abundance	Density (no./km)	stocked	most recent	source hatchery	stocking notes	source
	Seeger	1961		100	50%	yes	hdwtrs of Halleck Cr, prob. in western portion of Nicasio Cr.							6
	Peters	1954		61	30%	yes				yes	ongoing	Silverado Fisheries Base		6
Alameda Creek			1,658											
Alameda Creek	**Rubber Dam 1**			1,578	95%	yes				yes				
	Rubber Dam 3	1990		1,578	95%									
Calaveras Creek	Calaveras	1925		283	17%									
Arroyo Valle	Del Valle	1968		413	25%					yes				
Coyote Creek			757											
Coyote	**Standish**	1994		747	99%									
Coyote Creek	Coyote Percol	1934		532	70%									
Coyote River	Leroy Anderson	1950		487	64%									
Coyote Creek	Coyote	1936		278	37%									
	ESU Total		11,447	3,026	26%									
South Central California Coast														
Salinas River			9,966											
San Antonio Rv	**San Antonio**	1965		1,102	11%	yes	in reservoir, unknown if in stream			yes	ongoing	Silverado Fisheries Base		1, 7
Nacimiento Rv	**Nacimiento**	1957		761	8%	yes			330-390	yes	ongoing	Silverado Fisheries Base		7, 8
Salinas River	**Salinas**	1942		293	3%	yes				yes	ongoing	Silverado Fisheries Base	released at Lake Margarita marina	1, 7
Carmel River			656											
	San Clemente	1921		337	51%	SH								1, 7

ESU / Basin / Subbasin	Dam Name	Year Built	Total (km)	Above Barrier (km)	Above Barrier (%)	present	distribution	abundance	Density (no./km)	stocked	most recent	source hatchery	stocking notes	source
			---- Stream Length ----			*O. mykiss* above barrier								
	Los Padres	1949		128	20%	SH, RT				no		trap and truck of steelhead around Los Padres Dam for 20 yrs		1, 7
Big Sur Coastal			711											
Estero Bay Coastal			1,521											
Old Creek	**Whale Rock**	1960	44	42	95%	yes				yes		Whale Rock	55,000 total from 1992-2002 , broodfish taken from Whale Rock Reservoir	29
Arroyo Grande Cr	**Lopez**	1969	282	143	51%	yes				yes	ongoing	Silverado Fisheries Base		1
	ESU Total		19,213	2,469	13%									
Southern California														
Santa Maria River			5,775											
Cuyama River	**Twitchell**	1958		4,088	71%	yes	all tribs			yes	10-15 yrs ago (~1987-1992)			2
Santa Ynez River			2,619											
Santa Ynez River	**Bradbury**	1953		1,517	58%	yes	all tribs			yes	ongoing	Fillmore	into Lake Cachuma	2, 9, 10
Santa Ynez Rv	Gibraltar	1920		721	28%	yes	all tribs			yes	ongoing	Fillmore	not open to fishing?	2, 10
	Juncal	1930		49	2%	yes	all tribs	lots of RT, up to 26"		?	no stocking in last 30 yrs			2, 10, 28
Ventura River			644											

ESU / Basin / Subbasin	Dam Name	Year Built	---- Stream Length ---- Total (km)	Above Barrier (km)	Above Barrier (%)	*O. mykiss* above barrier present	distribution	abundance	Density (no./km)	stocked	most recent	source hatchery	stocking notes	source
Coyote Creek	**Casitas**	1959		131	20%	yes	where water present, note seasonal streams			yes	ongoing	Fillmore	32,000 pounds in 2002	2
Matilija Creek	**Robles Diversion**	1958		224	35%	yes								
	Matilija	1949		157	24%	yes				yes	5-6 yrs ago (~1996-97)	Fillmore		2, 11
Santa Clara River			3,851											
Santa Clara River	*Vern Freeman Diversion*	1991		3,830	99%	yes								2, 18
Piru Creek	**Santa Felicia**	1955		1,192	31%	yes	all tribs		2371-2940; 107-143 (>8"); 0 (>12")	yes	ongoing	Fillmore	Hot Creek strain, into Lake Piru and Frenchman's Flat	2
	Pyramid	1973		825	21%	yes	all tribs			yes	ongoing	Fillmore		2
Castaic Creek	**Castaic**	1973		378	10%	yes	reservoir and where water present, note seasonal streams			yes	ongoing		into Castaic Lake and Castaic Lagoon (below dam)	2
Malibu Creek			269											
	Rindge			264	98%									
subtotal			15,490	7,463	48%									
Los Angeles River			1,220											
Los Angeles River	**Sepulveda**[A]	1941		215	18%	no								2
Tujunga Wash	**Hansen**	1940		408	33%	yes	~5 miles or where water present	few fish		yes	ongoing	Fillmore		2
San Gabriel River			1,270											

ESU / Basin / Subbasin	Dam Name	Year Built	---- Stream Length ---- Total (km)	Above Barrier (km)	Above Barrier (%)	*O. mykiss* above barrier: present	distribution	abundance	Density (no./km)	stocked	most recent	source hatchery	stocking notes	source
San Gabriel River	**Whittier Narrows**[A]	1957		1,192	94%	yes	reservoir, but probably not far upstream			yes	ongoing	Fillmore		2
	Santa Fe	1949		692	54%	yes	reservoir, but probably not far upstream			yes	ongoing	Fillmore		2
	Morris	1935		626	49%	yes	reservoir			no, washdown from above				2
	San Gabriel No 1	1938		577	45%	yes	all tribs where there is water, EF usu perennial		1550-2706; 129-198 (>8"); 0 (>12")	yes	ongoing	Fillmore	in WF below Cogswell, NF, and EF of San Gabriel R	2, 21
	Cogswell	1935		121	10%	yes								2
Santa Ana River			4,620											
Santa Ana River	**Prado**[A]	1941		3,158	68%	yes								
Bear Creek						yes			96-732; 14-15 (>8"); 0 (>12")					20, 21
Upper Santa Ana River						yes			29-43; 0-14 (>8"); 0 (>12")					21
San Antonio Creek	San Antonio	1956		73	2%									
Santa Ana River	Seven Oaks	undrcnst		594	13%									
Tr Cajalco Cr	Mathews	1938		95	2%									
Santa Margarita River			1,604											
Temecula Creek	**Vail**	1949		655	41%					yes			private stocking	2
San Luis Rey River	**Henshaw**	1923	1,184	447	38%					yes	ongoing	Mojave	into WF of San Luis Rey	2
San Dieguito River	**Lake Hodges**	1918	693	618	89%	no				no			bass and catfish in L. Hodges	2
San Diego River	**El Capitan**	1934	1,013	558	55%	yes	in reservoir	few fish		no				2

ESU / Basin / Subbasin	Dam Name	Year Built	---- Stream Length ---- Total (km)	Above Barrier (km)	Above Barrier (%)	*O. mykiss* above barrier present	distribution	abundance	Density (no./km)	stocked	most recent	source hatchery	stocking notes	source
Sweetwater River	**Sweetwater Main**	1888	440	367	83%					yes	ongoing			2
Otay River	**Savage**	1919	410	333	81%									
Tijuana River[C]			734											
Cottonwood Cr	Barrett	1922		506										
	Morena	1912		210										
	ESU Total		31,964	15,414	48%									
Central Valley														
Sacramento River			52,206											
	Red Bluff Diversion	1964		14,261	27%	SH								
	Anderson Cottonwood	1917		9,224	18%	SH								
	Keswick	1950		9,189	18%	yes							SH from below dam transported above	
	Shasta	1945		9,106	17%	yes							see below	
Upper Sacramento			568											
	Shasta	1945				yes			4163-5468 (fish kill); 420-1670 (>4")	yes		Mt. Shasta ; Sacramento and McCloud River stocks	avg. 15,000 from 1994-1998; stocked at least since 1930, average of ~80,000 / yr; max. of 4M RT planted in 1936	16
	Box Canyon	1969		127	22%	yes								
Mc Cloud River			949											
	Shasta	1945				yes			2361 (>5")					4

ESU / Basin / Subbasin	Dam Name	Year Built	---- Stream Length ---- Total (km)	Above Barrier (km)	Above Barrier (%)	*O. mykiss* above barrier present	distribution	abundance	Density (no./km)	stocked	most recent	source hatchery	stocking notes	source
	McCloud	1965		474	50%	yes	all tribs		1864 (Squaw Valley Cr)	yes	ongoing below McCloud falls, ~7 yrs ago (~1994) above falls		15,000/yr into McCloud reservoir	4
Pit River			6,979											
	Shasta	1945				yes								
Fall River	Pit No 1 Diversn	1922				yes			1021-2541 (>6")					22
	Pit No 1 Forebay	1947				yes								
Hat Creek						yes			159-2539 (>8"); 32-1335 (>12")					19
Burney	Hat Cr No 2 Div	1942												
Clear Creek	**Whiskeytown**	1963	462	377	82%	yes	Whiskey Cr and Clear Cr		1553-3107	yes	ongoing	private hatchery		
Stony Creek			2,707											
Stony Creek	Stony Cr Gravel	1906												
	Black Butte	1963		2,427	90%	yes	migrate through Stony and Grindstone Crs, too warm in summer							13
	Stony Gorge	1928				yes	all tribs			yes	ongoing			13
Little Stony Creek	East Park	1910				yes	Trout Cr and Stony Cr seasonally			yes				13
Cache Creek			3,362											

ESU / Basin / Subbasin	Dam Name	Year Built	---- Stream Length ---- Total (km)	Above Barrier (km)	Above Barrier (%)	*O. mykiss* above barrier: present	distribution	abundance	Density (no./km)	stocked	most recent	source hatchery	stocking notes	source
Cache Creek	**Cache Cr Settling Bn**			3,362	100%									
Putah Creek			1,200											
Putah Creek	**Putah Div**	1957		1,087	91%									
	Monticello	1957		1,010	84%									
Feather River			9,094											
Feather River	Thermalito Div	1967												
	Feather R Hatchery	1964												
	Oroville	1968		7,702	85%									
Nfk Feather Rv	Poe	1959				yes							NF below L Almanor rotenoned at least 3x	12
	Lake Almanor	1927				yes				yes	ongoing	Eagle Lake strain	80,000/yr during last 15 yr	12
Bucks Creek	Bucks Storage	1928				yes				yes	ongoing		15-30,000/yr	12
Mfk Feather R						yes				yes			above wild trout section of MF	12
Nelson Creek						yes			155-621 (>6")					14
Yuba River			3,510											
Yuba River	**Englebright**	1941		2,923	83%									
Bear River			1,180											
	Camp Far West	1963		719	61%									
American River			4,480											
American River	**Nimbus**	1955		4,351	97%									
Rubicon River						yes								
Cosumnes River	Granlees[B]	1921	2,426	1,322	54%									24
Mokelumne River			1,877											
Mokelumne River	Woodbridge Diversion	1910		1,858	99%									

ESU / Basin / Subbasin	Dam Name	Year Built	---- Stream Length ---- Total (km)	Above Barrier (km)	Above Barrier (%)	*O. mykiss* above barrier present	distribution	abundance	Density (no./km)	stocked	most recent	source hatchery	stocking notes	source
	Camanche	1963		1,800	96%									
Calaveras River	**New Hogan**	1963	1,740	1,277	73%									
Stanislaus River			3,269											
Stanislaus River	**Goodwin**	1912		3,074	94%									
Tuolumne River			3,362											
Tuolumne River	**La Grange**	1894		3,170	94%									
Clavey River						yes			1,317					23
Merced River			2,574											
Merced River	**Crocker Diversion**	1910		2,129	83%									
subtotal			73,558	43,587	59%									
San Joaquin River			3,238											
San Joaquin River	Mendota Diversn	1917												
	Friant	1942		2,876	89%									
Upper MF San Joaquin						yes			273-2985; 119-695 (>6")	yes			RT prob not native	26
Kings River			3,570											
Kings River	**Pine Flat**	1954		2,819	79%									
Kern River			4,467											
Kern River	**Diversion No 1**	1906		3,952	88%									
	Isabella	1953		3,547	79%	yes			43-620	yes		Kern River Planting Base	50,500 lbs. / yr above Isabella	27
	ESU Total		103,504	53,234	51%									

A extensive portions of river below dam are channelized or concrete apron
B Granlees Dam is not considered a keystone barrier for steelhead, impassable natural falls below dam
C portion in California
1 pers. comm., Jennifer Nelson, CDFG
2 pers. comm., Dwayne Maxwell, CDFG
3 pers. comm., Dennis Maria, CDFG
4 pers. comm., CDFG Region 1 biologists; Mike Dean, Mike Berry, Randy Benthin, Bob McAllister, Bill Jong, Phil Bairrington
5 pers. comm., Scott Downie, CDFG
6 pers. comm., Bill Cox, CDFG
7 pers. comm., Mike Hill, CDFG
8 pers. comm., Joel Casagrande, Watershed Institute, CSUMB
9 pers. comm., Mauricio Cardenas, CDFG
10 pers. comm., Scott Engblom, Cachuma Operation and Maintenance Board
11 pers. comm., Rick Rogers, NMFS
12 pers. comm., Ken Kundargi, CDFG
13 pers. comm., Emil Ekman, USFS
14 CDFG 1979.
15 CDFG 1986.
16 CDFG 2000.
17 Jones 2001
18 McEwan and Jackson 1996
19 Deinstadt and Berry 1999
20 Deinstadt et al. 1993
21 Deinstadt et al. 1990
22 Rode and Weidlein 1986
23 Robertson 1985
24 Yoshiyama et al. 2001
25 Titus et al. 2001
26 Deinstadt et al. 1995
27 Stephens et al. 1995
28 pers. comm. to M. Capelli, Jim Adams, CDFG
29 pers. comm., John Bell, Whale Rock Hatchery

Overview

The above table summarizes available information on the distribution, abundance, and stocking of *O. mykiss* above recent barriers (Case 3) within the five listed steelhead ESUs in California. Populations above longstanding natural barriers (Case 2) and below barriers (Case 1) are not listed. Historically, coastal *O. mykiss* were broadly distributed in coastal watersheds and within the Central Valley (Behnke 1992, McEwan and Jackson 1996). Hatchery produced *O. mykiss* have been stocked for over 100 years (Behnke 1992) into streams and lakes throughout California by numerous state and federal agencies, private groups, and individuals. Given their broad historical range and widespread stocking over the last century, *O. mykiss* probably occur above all major recent barriers in California. However little specific information is available on their distribution and abundance above these barriers, and stocking records are incomplete and not centralized. Because of these limitations, this table is necessarily incomplete and is intended to provide information at the level of the ESU.

Methods and scope

Data were obtained from several sources. Barrier data were derived primarily from the California Department of Water Resources (DWR, 1993) and the National Inventory of Dams (NID) compiled by the U.S. Army Corps of Engineers. Data for a few dams were missing from these databases and were obtained from other sources. These databases list over 1400 unique dams on rivers and streams in California. Of these, fewer than 200 were classified as major barriers. A major barrier was arbitrarily defined as one that blocks or restricts access to ≥ 100 mi^2 of a watershed. Keystone barriers are the lowermost complete barrier to upstream migration in a watershed. For brevity, major barriers upstream of keystone barriers are not shown for the Central Valley ESU if there is no associated data on *O. mykiss*. A few minor barriers were included if information was available.

Stream lengths were derived from the National Hydrography Dataset (NHD) produced by the U.S. Geological Survey and U.S. Environmental Protection Agency. Total stream length for a watershed (or ESU) is the sum for all streams within the watershed (or ESU), not just streams or watersheds that are listed. Above barrier totals are the sum for all streams above the barrier (watershed) or above listed keystone barriers (ESU). The above barrier totals include sections of streams that may be above longstanding natural barriers and exclude streams above smaller keystone barriers that are not listed in the table.

Data on the distribution, abundance, and stocking of *O. mykiss* were obtained from the literature and from interviews with regional fish biologists with the California Department of Fish and Game, NMFS, and other agencies and academic institutions. Data on *O. mykiss* refer to fish that occur above the associated barrier but below the next upstream barrier, if it exists. Fish densities were converted from number per mile, but were not rounded to reflect true precision of estimate.

Appendix B.5.3. SSHAG (2003) categorizations of hatchery populations of 9 of the steelhead ESUs reviewed. See "Artificial Propagation" in General Introduction for explanation of the categories.

ESU	Stock	Run	Basin	SSHAG Category
Snake River	Wallowa	summer	Wallowa	3c
	Cottonwood	summer	Grande Ronde	3c
	Little Sheep Creek	summer	Imnaha	2a
	Oxbow	summer	Snake	3c
	Sawtooth	summer	Salmon	3c
	Pahsimeroi	summer	Salmon	3c
	Dworshak	summer	Clearwater	2a
	Lyons Ferry	summer	Snake	3c or 4
	Tucannon (Lyons Ferry)	summer	Tucannon	3c or 4
	Tucannon (new)	summer	Tucannon	1a
	Curl Lake	summer	Snake	3 or 4
Upper Columbia River	Wells	summer	Upper Columbia	2b
	Wenatchee	summer	Wenatchee	1b
Middle Columbia River	Deschutes (# 66)	summer	Deschutes	2a or 2c
	Umatilla (# 91)	summer	Umatilla	1a
	Dayton Pond	summer	Touchet	4
	Dayton Pond (new)	summer	Touchet	1a
Lower Columbia River	Skamania	summer	Washougal	4
	Sandy (ODFW 11)	winter	Sandy	1a
	Clackamas (#122)	winter	Clackamas	1a
	Hood (ODFW #50)	winter	Hood	1a
	Hood (ODFW #50)	summer	Hood	1a
	Big Creek/Eagle Creek	winter	Clackamas	4
	Chambers Creek	winter	various	4
	Cowlitz	late-winter	Cowlitz	2a
	Kalama	winter	Kalama	1a
	Kalama	summer	Kalama	1a
Upper Willamette River	Skamania (# 24)	summer	Santiam	4
Northern CA	Mad River	winter	Mad	3c
	Yager Creek	winter	Yager	1a
	N. Fork Gualala	winter	Gualala	1a
Central CA Coast	Don Clausen	winter	Russian	2a
	Monterey Bay	winter	Scott Creek	1a
South-Central CA Coast	Whale Rock	winter	Old Creek	1a or 2a
CA Central Valley	Coleman NFH	winter	Sacramento	2a
	Feather River	winter	Feather	2a
	Nimbus Hatchery	winter	American	4
	Mokelumne Hatchery	winter	Mokelumne	4

Appendix B.5.4. Steelhead Time Series References

Snake River Steelhead ESU

Population	Snake River Steelhead (total)
Years of Data, Length of Series	1980 - 2001, 22 years
Abundance Type	Total Live Count
Abundance References	12 ESU's data file, Eli Holmes, NWFSC
Abundance Notes	
Hatchery Reference	12 ESU's data file, Eli Holmes, NWFSC
Hatchery Notes	
Harvest Reference	US v. Oregon T.A.C. Spreadsheet from Henry Yuen
Harvest Notes	
Age Reference	12 ESU's data file, Eli Holmes, NWFSC
Age Notes	average

Population	Imnaha R (Zumwalt/Camp Creek)
Years of Data, Length of Series	1974 - 2000, 27 years
Abundance Type	Redds per Mile
Abundance References	updated spreadsheets from M. Chilcote, ODFW -2002
Abundance Notes	
Hatchery Reference	Chilcote 2001
Hatchery Notes	
Harvest Reference	Chilcote 2001
Harvest Notes	
Age Reference	Chilcote 2001
Age Notes	average

Population	Camp Creek (Imnaha)
Years of Data, Length of Series	1974 - 2002,. 29 years
Abundance Type	Total Live Count
Abundance References	Chilcote 2002
Abundance Notes	
Hatchery Reference	Chilcote 2002
Hatchery Notes	

Harvest Reference	Chilcote 2002
Harvest Notes	
Age Reference	Used Grande Ronde River aggregate
Age Notes	average

Population	Grande Ronde River, Upper
Years of Data, Length of Series	1967 - 2000, 34 years
Abundance Type	Redds per Mile
Abundance References	Chilcote 2001
Abundance Notes	
Hatchery Reference	Chilcote 2001
Hatchery Notes	
Harvest Reference	Chilcote 2001
Harvest Notes	
Age Reference	Chilcote 2001
Age Notes	average

Population	Joseph Creek
Years of Data, Length of Series	1974 - 2002, 29 years
Abundance Type	Total Live Count
Abundance References	Chilcote 2002
Abundance Notes	
Hatchery Reference	Chilcote 2002
Hatchery Notes	
Harvest Reference	Chilcote 2002
Harvest Notes	
Age Reference	Chilcote 2002
Age Notes	average

Population	Little Sheep Creek (Imnaha River) Hatch
Years of Data, Length of Series	1985 - 2002, 18 years
Abundance Type	Total Live Count
Abundance References	Chilcote 2002
Abundance Notes	
Hatchery Reference	Chilcote 2002

Hatchery Notes	
Harvest Reference	
Harvest Notes	
Age Reference	
Age Notes	

Population	Little Sheep Creek (Imnaha River) Wild
Years of Data, Length of Series	1985 - 2002, 18 years
Abundance Type	Total Live Count
Abundance References	Chilcote 2002
Abundance Notes	
Hatchery Reference	Chilcote 2002
Hatchery Notes	
Harvest Reference	Chilcote 2002
Harvest Notes	
Age Reference	Chilcote 2002
Age Notes	average

Population	Snake River A-run total
Years of Data, Length of Series	1985 - 2001, 17 years
Abundance Type	Total Live Count
Abundance References	Columbia River Basin Fish Mange Plan Tech. Adv Comm. 1996. All-Species Review; 1998-2000: spreadsheet sent from Peter Dygert & Enrique Patino, NMFS
Abundance Notes	
Hatchery Reference	Columbia River Basin Fish Mange Plan Tech. Adv Comm. 1996. All-Species Review; 1998-2000: spreadsheet sent from Peter Dygert & Enrique Patino, NMFS
Hatchery Notes	
Harvest Reference	Columbia River Basin Fish Mange Plan Tech. Adv Comm. 2002: spreadsheet sent from Henry Yuen, USFWS
Harvest Notes	
Age Reference	Columbia River Basin Fish Mange Plan Tech. Adv Comm. 2002: spreadsheet sent from Henry Yuen, USFWS
Age Notes	yearly

Population	Snake River B-run total
Years of Data, Length of Series	1985 - 2001, 17 years
Abundance Type	Total Live Count
Abundance References	Columbia River Basin Fish Mange Plan Tech. Adv Comm. 1996. All-Species Review; 1998-2000: spreadsheet sent from Peter Dygert & Enrique Patino, NMFS
Abundance Notes	
Hatchery Reference	Columbia River Basin Fish Mange Plan Tech. Adv Comm. 1996. All-Species Review; 1998-2000: spreadsheet sent from Peter Dygert & Enrique Patino, NMFS
Hatchery Notes	
Harvest Reference	Columbia River Basin Fish Mange Plan Tech. Adv Comm. 2002: spreadsheet sent from Henry Yuen, USFWS
Harvest Notes	
Age Reference	Columbia River Basin Fish Mange Plan Tech. Adv Comm. 2002: spreadsheet sent from Henry Yuen, USFWS
Age Notes	yearly

Population	Tucannon River
Years of Data, Length of Series	1987 - 2001, 13 years
Abundance Type	Total Live Count
Abundance References	Gallinat, et al. 2001, Mark Shuck, WDFW 2001 estimate
Abundance Notes	
Hatchery Reference	Gallinat, et al. 2001
Hatchery Notes	
Harvest Reference	Columbia River Basin Fish Mange Plan Tech. Adv Comm. 2002: spreadsheet sent from Henry Yuen, USFWS
Harvest Notes	
Age Reference	Gallinat, et al. 2001
Age Notes	average

Population	Wallowa River (GR)
Years of Data, Length of Series	1965 - 1996, 31 years
Abundance Type	Redds per Mile
Abundance References	Streamnet: trend 54572
Abundance Notes	
Hatchery Reference	

Hatchery Notes	
Harvest Reference	
Harvest Notes	
Age Reference	
Age Notes	

Population	Asotin Creek
Years of Data, Length of Series	1986 - 2001, 13 years
Abundance Type	Expanded Redd Count
Abundance References	Mark Schuck, WDFW (Feb. 2003)
Abundance Notes	
Hatchery Reference	
Hatchery Notes	
Harvest Reference	
Harvest Notes	
Age Reference	
Age Notes	

Upper Columbia Steelhead

Population	Above Wells Dam
Years of Data, Length of Series	1976 - 2001, 26 years
Abundance Type	Total Live Count
Abundance References	QAR - Cooney (2001)
Abundance Notes	
Hatchery Reference	Douglas PUD - Wells Dam broodstock sampling
Hatchery Notes	
Harvest Reference	QAR - Cooney (2001) TAC mainstem,WDFW trib. Rates
Harvest Notes	
Age Reference	Cooney (2001) WDFW - Priest Rapids Steelhead sampling program (Brown, 1995, WDFW annual update memos)
Age Notes	yearly

Population	Wenatchee + Entiat Rivers
Years of Data, Length of Series	1976 - 2001, 26 years

Abundance Type	Total Live Count
Abundance References	QAR - Cooney (2001)
Abundance Notes	
Hatchery Reference	Cooney (2001) WDFW - Priest Rapids Steelhead sampling program (Brown, 1995, WDFW annual update memos)
Hatchery Notes	
Harvest Reference	QAR - Cooney (2001) TAC mainstem,WDFW trib. Rates
Harvest Notes	
Age Reference	Cooney (2001) WDFW - Priest Rapids Steelhead sampling program
Age Notes	yearly

Population	Methow River
Years of Data, Length of Series	1976 - 2001, 26 years
Abundance Type	Total Live Count
Abundance References	QAR - Cooney (2001), 1999-2001 B.
Abundance Notes	
Hatchery Reference	Douglas PUD - Wells Dam broodstock sampling
Hatchery Notes	
Harvest Reference	QAR - Cooney (2001) TAC mainstem,WDFW trib. Rates
Harvest Notes	
Age Reference	Cooney (2001) WDFW - Priest Rapids Steelhead sampling program (Brown, 1995, WDFW annual update memos)
Age Notes	yearly

Middle Columbia Steelhead ESU

Population	John Day River, Upper North Fork
Years of Data, Length of Series	1977 - 2002, 26 years
Abundance Type	Redds per Mile
Abundance References	Chilcote 2001
Abundance Notes	updated spreadsheets from M. Chilcote, ODFW -2002
Hatchery Reference	12 ESU's data file
Hatchery Notes	
Harvest Reference	Chilcote 2002
Harvest Notes	

Age Reference	Chilcote 2001
Age Notes	average

Population	John Day River, Middle Fork
Years of Data, Length of Series	1974 - 2001, 28 years
Abundance Type	Redds per Mile
Abundance References	Chilcote 2001
Abundance Notes	updated spreadsheets from M. Chilcote, ODFW -2002
Hatchery Reference	12 ESU's data file
Hatchery Notes	
Harvest Reference	Chilcote 2002
Harvest Notes	
Age Reference	Chilcote 2001
Age Notes	average

Population	Deschutes River
Years of Data, Length of Series	1978 - 2002, 25 years
Abundance Type	Dam Count (Sherars)
Abundance References	Chilcote 2002
Abundance Notes	
Hatchery Reference	Chilcote 2002
Hatchery Notes	
Harvest Reference	Chilcote 2002
Harvest Notes	
Age Reference	Chilcote 2001
Age Notes	average

Population	Fifteenmile Creek (winter)
Years of Data, Length of Series	1964 - 2001, 24 years
Abundance Type	Redds per Mile
Abundance References	Streamnet
Abundance Notes	
Hatchery Reference	No annual sampling, assumed natural returns
Hatchery Notes	
Harvest Reference	Chilcote 2001

Harvest Notes	
Age Reference	Chilcote 2001
Age Notes	average

Population	John Day River, Lower Mainstem
Years of Data, Length of Series	1965 - 2002, 37 years
Abundance Type	Redds per Mile
Abundance References	Chilcote 2001
Abundance Notes	updated spreadsheets from M. Chilcote, ODFW -2002
Hatchery Reference	Chilcote 2001
Hatchery Notes	
Harvest Reference	Chilcote 2002
Harvest Notes	
Age Reference	Chilcote 2001
Age Notes	average

Population	John Day River, Upper Mainstem
Years of Data, Length of Series	1974 - 2002, 29 years
Abundance Type	Total Live Count
Abundance References	Chilcote 2002
Abundance Notes	
Hatchery Reference	Chilcote 2002
Hatchery Notes	
Harvest Reference	Chilcote 2002
Harvest Notes	
Age Reference	Chilcote 2001
Age Notes	average

Population	Shitike Creek (Deschutes)
Years of Data, Length of Series	1976 - 2002, 26 years
Abundance Type	Redds per Mile
Abundance References	updated spreadsheets from M. Chilcote, ODFW -2002
Abundance Notes	
Hatchery Reference	
Hatchery Notes	

Harvest Reference	
Harvest Notes	
Age Reference	Used Deschutes R ages
Age Notes	average

Population	John Day River, South Fork
Years of Data, Length of Series	1974 - 2002, 29 years
Abundance Type	Redds per Mile
Abundance References	Chilcote 2001
Abundance Notes	updated spreadsheets from M. Chilcote, ODFW -2002
Hatchery Reference	Chilcote 2001
Hatchery Notes	
Harvest Reference	Chilcote 2002
Harvest Notes	
Age Reference	Chilcote 2001
Age Notes	average

Population	Touchet River
Years of Data, Length of Series	1987 - 2001, 13 years
Abundance Type	Total Live Count
Abundance References	WDFW 1994, 1995, Bumgarner 2002 (1996-2001)
Abundance Notes	
Hatchery Reference	Streamnet: Touchet R natural (180065) divided by total (180065 + 180002)
Hatchery Notes	
Harvest Reference	Mainstem Harvest: T.A.C. spreadsheet, Tributary harvest: WDFW spreadsheet from Bob Leeland 05/24/2002
Harvest Notes	
Age Reference	
Age Notes	average

Population	Umatilla River
Years of Data, Length of Series	1966 - 2002, 35 years
Abundance Type	Total Live Count
Abundance References	Streamnet (1966-2000), Umatilla Tribal Fisheries 2002 (2001)
Abundance Notes	

Hatchery Reference	Chilcote 2002
Hatchery Notes	
Harvest Reference	Chilcote 2002
Harvest Notes	
Age Reference	Chilcote 2002
Age Notes	average

Population	John Day River, Lower North Fork
Years of Data, Length of Series	1976 - 2002, 27 years
Abundance Type	Redds per Mile
Abundance References	Chilcote 2001
Abundance Notes	updated spreadsheets from M. Chilcote, ODFW -2002
Hatchery Reference	Chilcote 2002
Hatchery Notes	
Harvest Reference	Chilcote 2002
Harvest Notes	
Age Reference	Chilcote 2002
Age Notes	average

Population	Walla Walla River
Years of Data, Length of Series	1993 - 2000, 8 years
Abundance Type	Total Live Count
Abundance References	ODFW 1998, Duke 2002 (1999-2001)
Abundance Notes	
Hatchery Reference	Chilcote 2001
Hatchery Notes	
Harvest Reference	Chilcote 2001
Harvest Notes	
Age Reference	Chilcote 2001
Age Notes	average

Population	Warm Springs National Fish Hatchery
Years of Data, Length of Series	1980 - 1999, 20 years
Abundance Type	Total Live Count
Abundance References	Chilcote 2001

Abundance Notes	
Hatchery Reference	Chilcote 2001
Hatchery Notes	
Harvest Reference	Chilcote 2001
Harvest Notes	
Age Reference	Chilcote 2001
Age Notes	average

Population	Yakima River
Years of Data, Length of Series	1980 - 2001, 23 years
Abundance Type	Total Live Count
Abundance References	From WDFW Spreadsheet 06/12/2002
Abundance Notes	
Hatchery Reference	From WDFW Spreadsheet 06/12/2002
Hatchery Notes	
Harvest Reference	Table 4-3, Biological Assessment, Yakima Operations and Maintenance, Upper Columbia Area Office, BR , Aug. 2000
Harvest Notes	
Age Reference	From WDFW Spreadsheet 06/12/2002
Age Notes	average

Population	Klickitat River
Years of Data, Length of Series	1990 - 2002, 9 years
Abundance Type	Redd Count
Abundance References	From Rolf Evenson, YIN Fisheries Biologist
Abundance Notes	
Hatchery Reference	
Hatchery Notes	No recent year data available
Harvest Reference	
Harvest Notes	
Age Reference	
Age Notes	

Lower Columbia River Steelhead ESU

Population	Hood River summer-run steelhead
Years of Data, Length of Series	1992 - 2000, 9 years
Abundance Type	Dam/weir count
Abundance References	Gorman, Leah. 2001.
Abundance Notes	Dam counts at Powerdale dam
Hatchery Reference	Gorman, Leah. 2001.
Harvest Reference	No Harvest Data Available.
Age Reference	Gorman, Leah. 2001.
Age Notes	Repeat % total ranged from 2% to 10%.

Population	Kalama River summer-run steelhead
Years of Data, Length of Series	1977 - 2003, 27 years
Abundance Type	Trap Count
Abundance References	Rawding, Dan (WDFW). 2002a.
Abundance Notes	Trap count plus correction estimate for jumpers
Hatchery Reference	Rawding, Dan (WDFW). 2002a.
Hatchery Notes	Work done at RM 10 above the two hatcheries to minimize handle of hatchery fish. Substantial rearing may occur below; trapping takes place during spring
Harvest Reference	Rawding, Dan (WDFW). 2002a.
Age Reference	Rawding, Dan (WDFW). 2002a.
Age Notes	From 1998 forward no scales have been aged and mean ages are used for these years

Population	Washougal River summer-run steelhead
Years of Data, Length of Series	1986 - 2003, 18 years
Abundance Type	Index
Abundance References	WDFW. 1997. Rawding 2002a
Hatchery Reference	No Hatchery Data.
Harvest Reference	No Harvest Data Available.
Age Reference	Busby et al.1996; Chilcote, M. W. 2001; Hulett et al. 1995.
Age Notes	Generic sum age structure

Population	Wind River summer-run steelhead
Years of Data, Length of Series	1989 - 2003, 15 years
Abundance Type	Mark recapture
Abundance References	Rawding, Dan (WDFW). 2001b; Rawding 2002a.
Abundance Notes	Estimates made from mark-recapture from trap efficiency method. Adult trap at Shiperd Falls but adult population is estimate by M-R, since fish jump the falls. Not able to differentiate winter and summer-run steelhead smolts
Hatchery Reference	Rawding, Dan (WDFW). 2001b.
Harvest Reference	Rawding, Dan (WDFW). 2001b.
Age Reference	Rawding, Dan (WDFW). 2001b.
Population	Clackamas River winter-run steelhead
Years of Data, Length of Series	1958 - 2001, 44 years
Abundance Type	Dam/weir count
Abundance References	Cramer, Doug. 2002a.
Abundance Notes	Abundance data delivered via Kathryn Kostow, Or Dept of Fish and Wildlife
Hatchery Reference	Cramer, Doug. 2002a.
Hatchery Notes	Pre-1997 Wild Fraction determined by run timing; all fish counted on or after March 1 assumed to be Wild. Additional reference for 1997-2001 from Doug Cramer, PG; have #s for wild and hatchery fish as of 1996-1997 run; all winter steelhead trapped and identified as wild or hatchery
Harvest Reference	ODFW 1999. Personal Communication. Personal communications for reconstructed run year estimates from punch cards for steelhead, 1956-1970
Age Reference	Busby et al.1996; Chilcote, M.W. 2001; Hulett et al. 1995.
Age Notes	Generic sum age structure
Population	Upper Cowlitz, Cispus and Tilton winter-run steelhead
Years of Data, Length of Series	2002, 1 year
Abundance Type	Dam/weir count
Abundance References	Serl and Morrill 2002
Abundance Notes	Abundance data delivered via Kathryn Kostow, Or Dept of Fish and Wildlife
Population	East Fork Lewis River winter-run steelhead

Years of Data, Length of Series	1985 - 1994, 10 years
Abundance Type	Peak Count
Abundance References	Johnson, T.H. and R. Cooper. 1995.
Abundance Notes	Natural population only; East Fork Lewis River, trib to Lewis River from mile 0.0 to mile 41.8
Hatchery Reference	Busby et al. 1996. Status review of west coast steelhead from WA, ID, OR and California
Harvest Reference	No Harvest Data Available.
Age Reference	Busby et al.1996; Chilcote, M.W. 2001; Hulett et al. 1995.

Population	Hood River summer-run steelhead
Years of Data, Length of Series	1992 - 2000, 9 years
Abundance Type	Dam/weir count
Abundance References	Gorman, Leah. 2001.
Abundance Notes	Dam counts at Powerdale dam
Hatchery Reference	Gorman, Leah. 2001.
Harvest Reference	No Harvest Data Available.
Age Reference	Gorman, Leah. 2001.

Population	Kalama River winter-run steelhead
Years of Data, Length of Series	1977 - 2002, 26 years
Abundance Type	Trap Count
Abundance References	Rawding 2001b; Rawding 2002a.
Abundance Notes	Trap count plus correction estimate for jumpers
Hatchery Reference	Rawding 2001b.
Hatchery Notes	Work done at RM 10 above the two hatcheries to minimize handle of hatchery fish. Substantial rearing may occur below; trapping takes place during spring
Harvest Reference	Leland 2003.
Age Reference	Rawding 2001b.
Age Notes	From 1998 forward no scales have been aged and mean ages are used for these years

Population	North Fork Toutle River winter-run steelhead
Years of Data, Length of Series	1989 - 2002, 14 years
Abundance Type	Total from redd count

Abundance References	Rawding 2001b; Rawding 2002a.
Abundance Notes	100% trap count
Hatchery Reference	Rawding 2001b.
Harvest Reference	Rawding 2002a.
Age Reference	Rawding 2001b.
Population	Sandy River winter-run steelhead
Years of Data, Length of Series	1978 - 2001, 24 years
Abundance Type	Dam/weir count
Abundance References	Cramer, Doug. 2002.
Abundance Notes	Dam counts made at Marmot Dam
Hatchery Reference	Chilcote, Mark. 1998.
Hatchery Notes	Used average hatchery fraction from 1978-1997 for years 1998-2001.
Harvest Reference	Berry, R.L. 1978.
Harvest Notes	Natural population catch determined by multiplying harvest by wild fraction
Age Reference	Busby et al.1996; Chilcote, Mark. 1998; Hulett et al. 1995.
Age Notes	Generic winter age structure
Population	South Fork Toutle River winter-run steelhead
Years of Data, Length of Series	1981 - 2002, 19 years
Abundance Type	Redd Surveys
Abundance References	Leland 2003; Rawding 2001b; Rawding 2002a.
Abundance Notes	Winter steelhead in S. Fork Toutle River are by redd surveys from March 15 to May 31. Redd surveys assume that you see 100% of the redds, only wild steelhead spawn after March 15, sex ratio is 1:1, and each redd represents 0.8 females. Assumed 2% stray rate
Hatchery Reference	Rawding 2001b.
Harvest Reference	Rawding 2001b.
Age Reference	Rawding 2001b.
Age Notes	Applied Kalama estimates to S. Fork Toutle River. Pooled ages 6 and 7 into age 6 to increase r/s sample size.

Population	Washougal River winter-run steelhead
Years of Data, Length of Series	1991 - 2002, 5 years
Abundance Type	Redd index
Abundance References	Leland 2003; WDFW 1993.
Hatchery Reference	Leland 2003; WDFW 1993.
Hatchery Notes	Reports little hatchery impact
Harvest Reference	No Harvest Data Available
Age Reference	Busby et al.1996; Chilcote, M.W. 2001; Hulett et al. 1995.
Age Notes	Generic winter age structure

Population	Coweeman River winter-run steelhead
Years of Data, Length of Series	1987 - 2002, 16 years
Abundance Type	Redd Surveys
Abundance References	Leland 2003; Rawding 2001b; Rawding 2002a.
Abundance Notes	Winter steelhead estimate in the Coweeman River are by redd surveys from Mar 15 to May 31. Redd surveys assume that you see 100% of the redds, only wild steelhead spawn after March 15, sex ratio is 1:1, and each redd represents 0.8 females.
Hatchery Reference	Leland 2003; Rawding 2001b.
Hatchery Notes	Data on hatchery fraction for 1987-1989 were provided by Leland (2003), estimate for 1990-2002 based on estimate from Rawding of 50% hatchery.
Harvest Reference	Leland 2003. Rawding 2001b.
Age Reference	Rawding 2001b.
Age Notes	Only age structure data is for winter-run in N. Fork Toutle and Kalama Rivers, and summer-run in the Kalama. Age structure is very similar in Toutle and Kalama River winter-run. Toutle River has less repeats 5.3% to 8.9% possibly because kelts must pass through PVC tubes on the Sediment Dam, which negatively impacts their survival. Rawding applied the Kalama River winter-run to the Coweeman and S. F Toutle Rivers populations.

Population	East Fork Lewis River summer-run steelhead
Years of Data, Length of Series	1996 - 2003, 8 years
Abundance Type	snorkel survey
Abundance References	Rawding, Dan. 2002a.

Hatchery Reference	Rawding, Dan. 2002a.
Harvest Reference	Rawding, Dan. 2002a.
Age Reference	Rawding, Dan. 2002a.

Upper Willamette River Steelhead ESU

Population	Calapooia River winter-run steelhead
Years of Data, Length of Series	1980 - 2000, 21 years
Abundance Type	Redd Count
Abundance References	Anonymous 1995; Anonymous 1997; Hunt, Wayne. 1999.
Abundance Notes	Data from StreamNet
Harvest Reference	Chilcote, Mark. 2001
Hatchery Reference	Chilcote, Mark. 2001
Population	South Santiam River winter-run steelhead
Years of Data, Length of Series	1983 - 2000, 18 years
Abundance Type	Redd Count
Abundance References	Anonymous 1995; Anonymous 1997
Abundance Notes	Data from StreamNet
Harvest Reference	Chilcote, Mark. 2001.
Hatchery Reference	Chilcote, Mark. 2001
Population	North Santiam River winter-run steelhead
Years of Data, Length of Series	1983 - 2000, 18 years
Abundance Type	Redd Count
Abundance References	Anonymous 1998; Anonymous 1998.
Abundance Notes	Data from StreamNet
Harvest Reference	Chilcote, Mark. 2001.
Hatchery Reference	Chilcote, Mark. 2001
Population	Molalla River winter-run steelhead
Years of Data, Length of Series	1980 - 2000, 21 years

Abundance Type	Redd Count
Abundance References	Anonymous 1997; Hunt, Wayne. 1999.
Harvest Reference	Chilcote, Mark. 2001.
Hatchery Reference	Chilcote, Mark. 2001
Population	South Santiam River (Foster Dam)
Years of Data, Length of Series	1973 - 2000, 28 years
Abundance Type	Total Live Fish
Abundance References	ODFW 1990; Anonymous 1997; Anonymous 1994; Hunt, Wayne. 1999.
Harvest Reference	Chilcote, Mark. 2001.
Population	Willamette Falls Dam winter-run steelhead
Years of Data, Length of Series	1971 - 2002, 32 years
Abundance Type	Dam/weir count
Abundance References	Kostow, Kathryn. 2002.